Before the
Federal Communications Commission
Washington, D.C. 20554

In the Matter of	)	
	)	
Comments Sought on the Implementation Of Smart Grid Technology	)	
	)	GN Docket Nos. 09-47, 09-51, 09-137
	)	
NBP Public Notice #2	)	
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	)	

COMMENTS OF THE AMERICAN PUBLIC POWER ASSOCIATION

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October 2, 2009

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To: The Commission

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The American Public Power Association ("APPA") appreciates this opportunity to respond to the Federal Communications Commission ("FCC") regarding its Public Notice on Comments Sought on the Implementation of Smart Grid Technology.

I. INTEREST OF APPA AND ITS MEMBERS

APPA is the national service organization that represents the interests of more than 2,000 publicly-owned, not-for-profit electric utilities located in all states except Hawaii. Many of these utilities developed in communities that were literally left in the dark during the era when the United States was electrified, as private-sector electric companies pursued opportunities in larger population centers. State and local governments therefore undertook the effort to ensure that residents of these communities were served by their own power systems, in recognition that electrification was critical to their economic development, educational opportunity, and quality of life. Public power systems also emerged in several large cities – including Austin, Cleveland, Jacksonville, Los Angeles, Memphis, Nashville, San Antonio, Seattle and Tacoma – where residents believed that "yardstick" competition from public power entities was necessary to obtain lower prices, higher quality of service, or both. Currently, over 70 percent of APPA's members serve communities with less than 10,000 residents, and approximately 45 million Americans receive their electricity from public power systems operated by municipalities, counties, authorities, states, or public utility districts.

II. APPA GENERAL COMMENTS

The term "Smart Grid" has many meanings to many people. Recently "Smart Grid" investments in the electric grid have been highlighted by the national news media, Congress and the Administration. However, there is often confusion by what the term means. Worse yet, the term could be construed to imply that electric utilities and the nation's electric power delivery system are not functioning well, when in fact we have an outstanding record of reliability. In the past, technological advancements have been focused on actual assets like transmission lines, substations and power plants. To APPA, the "Smart Grid" means utilizing our existing infrastructure to its fullest potential, and upgrading it on a cost-effective basis to obtain additional efficiencies and benefits for retail customers. While we don't disagree that advanced technologies have the ability to do more and make electric utilities "smarter" about their system operations, the industry does not often get credit for many of the measures that are already in place that make the grid run "smartly." APPA's membership is concerned that every small advancement in technology (even if it is cost-effective and commercially-demonstrated technology), will have to carry the "Smart Grid" label to be considered.

While speed and impact are the features first reviewed when considering investing in advanced information technology, the features of most benefit to electric utilities when considering new technology investments are safety and connectivity. Technological advancements can often significantly improve the response time to deal with any disruption on the grid. Moreover, the safety of our employees and public are still and will always be of the utmost importance to our operations.

APPA recently released a document entitled "Smart Grid Essentials" to its membership (copy attached). The intent of this document is to explain to our members what Smart Grid is and is not, and what it can do to help consumers, distribution systems, transmission systems and generation operations. The document highlights the changing relationship between the utility and the consumer. In the past, the electric utility industry operated in a linear fashion: utilities generated electricity that was then transmitted first over transmission and then over distribution lines to the end use retail customer, who consumed it. With evolving technology, including distributed generation, renewable generation, increased ability to store electricity, and two-way meter communications, the user and utility have the ability to interact and modify consumption, impacting overall demand for electricity over time like never before.

When APPA's members were surveyed regarding their major objectives for implementing Smart Grid technologies, they responded as follows: (1) maximize the effective use and investment in existing grid assets; (2) bring more detailed information about end use loads and their effects on the system into utility operations; (3) coordinate capabilities of high load appliances, consumers and distributed generation in order to assist in maintaining high system reliability while reducing customer costs; and (4) improve the process of balancing energy supply with real-time demands to minimize utility operating costs through more effective load control and response.

Components of the electrical grid that already exist or are in place that APPA believes will grow as technology advances include: (1) intelligent home area networks and appliances; (2) advanced metering systems; (3) two-way communication between customer networks and the utility; (4) processing of real-time information about generation, distribution and transmission systems; (5) use of data and system controls to integrate customer load into the distribution, transmission and generation optimization process; (6) continued education of the consumer to take advantage of the information and choices available and; (7) data and information flow across the utility. For those in the utility business, these concepts are not new. However, improvements to these areas certainly can make electrical systems "smarter."

APPA's "Smart Grid Essentials" document focused on five overall areas which we define as parts of the "Smart Grid" concept. Those areas identified were: Smart Customers; Smart Distribution Systems; Smart Transmission; Smart Generation; and Smart Communication and Meters. The Smart Customer describes an individual customer who can be active in managing his or her personal consumption. While technological advancements in appliances, home area networks and meters can improve system operations. Studies have shown that providing information as simple as the varying cost of electricity from hour to hour can result in reductions as great as 10 percent of overall demand on peak. Time-of-use-rate programs and interruptible rates have been employed by various utilities for decades, and many systems are currently implementing time-varying rates of one type or another. The most effective approach APPA members have seen to date when working with their large commercial and industrial customers is the use of interruptible rates and load curtailment or utility controlled curtailment programs of residential water heaters, HVAC, etc. Large scale application and effectiveness of these programs has been hampered, however, by customer concerns about loss of control over their usage and decreased comfort levels. However, capitalizing on the advances in technology in customers' appliances and use of home area networks, and then linking this real time information back to the utility could decrease the need for manually controlling customer usage, and give customers themselves an increased sense of "ownership" of their usage. The automatic adjustment and control of customer load (vs. the manual and resource intensive data collection) will help both the utility and customers minimize costs. This real time two-way communication between the customer and utility can be achieved through advanced metering which allows for the flow of price and usage information.

Smart Distribution Systems are ones that are more efficient and reduce losses attributed to serving load. Currently, if an interruption occurs at one location, all load from that point outward is removed from the system. Future smart systems will be equipped with more switching capabilities to help isolate damaged sections while continuing to serve as many customers as possible. The continued development of smarter distributed generation such as combined heat and power (CHP) units or distribution-level renewable energy sources can help serve the system load thru "micro-grids" or small pockets. "Smart Grid" concepts could allow for the proper monitoring and control of these areas to maximize the potential for customer and utility, all while offering proper interconnection and safety standards and procedures for utility employees and the public. For the most part, the monitoring of assets like distribution lines is currently done manually. As technology advances, monitoring of these assets can be done remotely to improve power quality and reliability and extend the life of distribution devices by finding problems before failures occur.

By optimizing (when possible) distribution feeder line configurations and minimizing long distance power flows on distribution systems, the "Smart Grid" can also reduce line losses. According to the U.S. Department of Energy, the average distribution system loses about 7 percent due to load loss. An improvement of as little as 1 percent could make a huge impact on the efficiency of an electric distribution system.

Similar considerations enter into evaluation of Smart Transmission installations. The system is already equipped with the ability to monitor and control to minimize outages. However, faster and more widespread data collection is needed to understand vulnerabilities resulting from certain events. This type of intelligence would allow for utilities and system operators to avoid outages in some cases and assist in avoiding wide-spread outages in others. Information could be read in real-time from a central location where adjustments could be made to a relay setting or voltage control so load shedding at a substation could be managed without having to dispatch a crew. Early warning can be key to asset management and critical to preventing outages.

The end goal of Smart Generation is to ensure that power quality is maintained and sufficient reserve capacity is always available for the grid. This has always been a key goal of electrical grid operations. Maintaining reserves and standby generation have always required significant investment. Integrating non-dispatchable resources like wind and solar generation into the grid will entail additional costs to maintain these reserves. Having a smarter grid that can control end-use load can help reduce the impact of the control issue associated with solar and wind resources. A smarter grid can provide for more efficient operation of generation and reduce maintenance impacts on units from frequent cycling. Storage devices such as thermal energy storage and batteries could help lower the cost of frequency control and allow for the smoother integration of renewable resources.

The success of the Smart Grid, although defined differently by the various standards, guidebooks, associations and academics, boils down to data management in its most simplistic form. The future electric system that has been called the 'Smart Grid' is not that different physically than it is has been over the past 100 years. Generators will still need to produce electrons. The electrons will still need to be transmitted and/or distributed by hard wires for consumption by the end consumer. Some type of metering will be used to register the amount of consumption by the customer. These basic laws of physics will not change – there will not be cellular electricity where electrons flow thru the air. There will not be 100 percent reliability throughout the United States as long as trees, animals, and natural disasters/storms exist, and safety to the utility employee is a concern. The smart grid for many is the ability to measure and control the existing electric grid by the advanced ability to collect and utilize real-time data.

This data management task will be enormous. As some are fond of saying - "think terabits, not megabits." The collection of such data will only be enabled by a strong communications system overlying the entire smart grid. Whether it is a fiber backbone, a citywide wi-fi/wi-mesh system, or a legacy hardwired coaxial SCADA or telephony system, the amount of data that will be collected will only grow as the system evolves and expands. The access to existing public and private networks will be crucial. If the data collected at the consumer level cannot easily and inexpensively be relayed back to the utility or a third party data collection center, the benefits of this future 'smarter grid' will be much less than expected.

APPA has recommended to its membership that a smarter grid is best accomplished when a utility employs a systematic and "core process outward" approach. A Smart Grid is not accomplished by simply installing an AMR or AMI system. Smart Grid is also not accomplished merely by enabling Plug-in Hybrid Electric Vehicles (PHEV'S) to consumer sites. The list could go on. Instead, Smart Grid can only be accomplished by working toward the end consumer with data management as one of the most important concerns. Questions surrounding how the data will be collected, how it is processed, how it will be used to control usage, etc., must be answered before a utility starts to change out meters. Backbone items such as relaying, distributed automation, interconnection of CHPs and other small generators will need to be thought out prior to data collection. APPA members have told us quite plainly that a system which installs a Meter Data Management Systems (MDMS) *after* installing smart grid enabled hardware is in for operational difficulty.

In addition to the concerns as to the amount of data that will be collected and what a utility can do effectively with it, the security of this same data is of utmost importance. Regardless of the communication spectrum and medium used (Wireless, BPL, PLC, Fiber, etc.) the security of that data is crucial to enabling the Smart Grid. Manufacturers of Smart Grid equipment, including metering, relays, end use appliances, and all other software applications that will enable the Smart Grid need to build security into their applications up front. The National Institute of Standards and Technology (NIST) and the appointed Standards Development Organizations (SDOs) are attempting to ensure compatibility, open protocols, etc., that will allow the system to work and ensure software and hardware systems "speak" to each other. APPA urges the Commission to work within the NIST structure to ensure that the communication systems that make up the backbone of the Smart Grid are not just hearty enough to handle the amount of data needed, but are also secure from outside intrusion that could defeat the automated effectiveness of the digital smart grid.

III. COMMENTS ON QUESTIONS IN THE FCC NOTICE.

APPA's answers to the specific questions posed by the Commission in its Notice are in many cases found in the attached "Smart Grid Essentials" document. As noted above, that document focused on five overall areas which APPA defines as parts of the "Smart Grid" concept: Smart Customers; Smart Distribution Systems; Smart Transmission; Smart Generation; and Smart Communication and Meters.

Answers to Question 2- Availability of Communications Networks, Question 4- Real-time Data, and Question 5- Home Area Networks are all found within the document. APPA, however, sets out only broad perspectives of where smart grid concepts could apply, because not all applications make sense for every public power utility. Individual utilities may not have the need, resources or infrastructure backbone to support various concepts or technologies. However, we do believe that there is something for everyone in the application of "Smart Grid" concepts.

2) Availability of Communications Networks.

2a.) What percentage of electric substations, other key control infrastructure, and potential Smart Grid communications nodes have no access to suitable communications networks?

APPA is not aware of any electric substation that does not have some form of communication to the substation, when such communication is needed for proper system functioning. The decision about which type of communication to use depends on many physical factors, such as location, proximity to existing communication infrastructure, and space constraints in the substation. All of these variables, and many more, are evaluated when the utility does its cost benefit analysis to consider such communications options. Each analysis for the 2,010 public power utilities may produce 2,010 different solutions, but one thing will be consistent among those different solutions: cost. As these substations take on additional smart grid functionality above and beyond the standard SCADA requirements, there will be greater demand for higher bandwidth communication infrastructure to support that functionality. But public power rarely waits for the communication industry to provide the necessary bandwidth for mission critical projects. Electric substations are designed with these communication facilities in mind, using leased lines, unlicensed spectrum, fiber optic, microwave, cellular, broadband over power lines or any other available options. APPA believes that having as many options as possible at a utility's disposal provides it with more competitive, cost effective solutions for smart grid installations.

2c.) In areas where suitable communications networks exist, are there other impediments preventing the use of these networks for Smart Grid communications?

In some areas of the country, public power utilities are not allowed to utilize publicly funded broadband networks for use in the electric distribution system. "Barriers to entry" have been erected that either explicitly prevent or have the effect of barring municipalities from being involved in advanced telecommunications.

2d.) How does the availability of a suitable broadband network (wireless, wireline or other) impact the cost of deploying Smart Grid applications in a particular geographical area?

Again, APPA believes that utilities will build their smart grid installations with the understanding that the communication portion is critical to the effectiveness of the project. Remote facilities will be most impacted by the lack of suitable broadband networks and the cost of installation. Procurement of adequate bandwidth may also reduce the scale of the smart grid installation.

Questions 4 and 5 of the Public Notice are encompassed within our discussion of the final section of our primer. Smart Communication and Meters will be essential in providing the two-way communication necessary between the utility operation center and the individual meters on the system. We addressed some of these issues under the Smart Customer heading above. However, numerous issues exist around this framework. They involve application and data strategy, system monitoring and control, and the need for a security and compliance framework.

IV. CONCLUSION

APPA believes that there is a role for the implementation of smart grid technologies as long as they are proven and cost effective. We also agree that the federal government should play the lead role in defining exactly what "Smart Grid" means so that lawmakers, media, stakeholders, utilities and their customers all have a common understanding of what the term means. Many public power systems are already investing in communications systems to homes, distribution automation, advanced meters, customer-side devices and other demand response applications that might be labeled as "Smart Grid" technologies. However, we also agree that many components of the system have yet to be developed.

APPA also has growing concerns that as the industry builds toward a smarter grid with advanced technologies, many smaller public power systems will be left out. Currently, numerous "barriers to entry" exist throughout the United States that prohibit, or have the effect of prohibiting, smaller public power systems from being involved in advanced telecommunications. APPA and its members have fought for years to be able to have, when asked by the community, the legal ability to provide these type of services. Even as the United States has continued to fall behind the world in deployment of broadband services, these barriers to entry have remained; indeed, attempts to raise them higher have continued. APPA has advocated for a legislative remedy to this problem by supporting the Community Broadband Act, which over the last several Congresses has been introduced in both chambers. We therefore urge the Commission to take into consideration the effect such barriers to entry for public power systems could have on the growth of broadband deployment in the United States and the unintended consequences it could have on our utilities deploying Smart Grid technologies.

DEED

American Public Power Association

Smart Grid Essentials

A Public Power Primer

Smart Grid Essentials

A Public Power Primer

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This publication was funded by a grant from the Demonstration of Energy-Efficient Developments (DEED) Program.

Preface

This guide to the smart grid discusses what the smart grid is, and what it is not. Components of the smart grid are here today, while other parts are still in the developmental stages. The current dialogue about smart grid in Washington, D.C., is supported with significant funding from the federal government. The intent of this guide is to increase the understanding of the smart grid's benefits so any investment can provide value to the utility and its customers.

This guide provides background about what the smart grid can do to help consumers, distribution systems, transmission systems and generation operation. Examples of specific uses of the smart grid for each of these categories are provided. Information about the system opportunities from the home to the power plant is included. As we move into the era of plug-in hybrids and distributed generation, utility managers and employees need to have a working knowledge about what technologies are commercially available and what is still in development.

APPA conducted an online survey of its members to gain feedback and insight into smart grid issues facing public power utilities. There were 120 survey respondents and the results of many of the questions are shown as charts throughout this document.

This publication has been prepared by Burns & McDonnell for the American Public Power Association (APPA) through a grant from the Demonstration of Energy-Efficient Developments (DEED) program.

Special thanks to Kiah E. Harris, Principal, Management Services Group, Burns & McDonnell, who authored this guidebook.

Thank you also to the following individuals who contributed to the development of this publication:
- Nathan Mitchell P.E., Director of Electric Reliability Standards and Compliance, APPA
- Mike Hyland P.E., Vice President of Engineering Services, APPA
- Jeanne LaBella, Vice President Publications, APPA

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Executive Summary

Smart grid. So many things to so many people. The holy grail of the utility industry? The investment that will bring the electric system to the digital age? The silver bullet?

The term smart grid was crystallized after the major blackout in the Northeastern United States on August 14, 2003. Analysis of that event showed that if additional intelligence about the conditions of the grid had been more widely known earlier, the extent of the blackout could have been reduced, if not avoided altogether. From this origin of increased transmission system reliability, the concept of the smart grid has broadened into a concept that affects all aspects of the system from the consumer to the generator.

The smart grid is coming – of that we can be sure. Whether you are a load-serving, distribution-only utility or a vertically integrated generation, transmission and distribution utility, you need to know about the various opportunities and challenges of the smart grid. Several definitions of the smart grid exist. The main attributes include bringing sustainable energy use options to the consumer while increasing the efficiency of and maximizing the investment in the electric power system that serves them.

The main components of this system will be:

- Intelligent home area networks and appliances
- Advanced metering systems
- Two-way communication between the customer's network and the utility
- Faster, forward-thinking controllers processing real-time information about the generation, distribution and transmission systems
- Increased data and system controls allowing integration of customer load into the distribution, transmission and generation optimization process
- Re-education of the industry on how to make it work seamlessly and education of the customer to take advantage of the information and choices
- Increased data and information flow across the utility enterprise

The system will allow all segments of the industry to get "smarter."

Smart Customers

Customers will be able to participate from any level of passive to active management of their personal consumption. Although smarter appliances, home area networks and advanced metering are all needed to make the system work at its fullest capabilities, we can start now to obtain benefits from simply providing information to consumers about the cost of electricity from hour to hour. Case studies have shown reductions of 10 percent or more of peak demand simply from alerting consumers about the time varying cost of electricity.

As the home network and appliance intelligence increases, the need for consumers to manually control their usage will diminish. It could automatically adjust based on customer-programmed directives. Extensive management of consumers' load by the utility could minimize cost to the consumer and utility, benefiting both. More transparent use of consumer load by the utility could increase the participation in demand response programs.

The application of advanced metering will not only provide better information to the customer and utility about consumption issues, but also provide power quality information. Better intelligence about voltage quality at each consumer location will decrease outage response time.

Smart Distribution Systems

The smart grid holds the promise of helping make the distribution system more efficient and reducing the losses attributed to serving load. Management of peak loading will help to reduce the losses and extend the useful life of the system. The smart grid will also assist in serving increased loads, like the plug-in hybrid electric vehicles (PHEV), while using the same infrastructure. Without some means of controlling vehicle charging within distribution line and transformer capabilities, significant system upgrades may be necessary where multiple PHEV customers are served from a single transformer.

In the future, distribution systems will be equipped with more switching capability to isolate damaged sections and keep service to as many customers as possible. With intelligence about power quality coming in from each meter, precise isolation of damaged system elements will be possible. This will allow as much of the system to remain energized as switching will allow.

Customers and utilities are installing more distributed generation. This can take the form of back-up engine sets, combined heat and power systems, wind turbines and solar panels. The smart grid will allow the use of this distributed generation and the system's increased switching capability to create "micro-grids" where islands of load can be served at a reduced level with the distributed generation available during outage. This can all be possible while maintaining the safety necessary for the line crews repairing the system.

Smart Transmission

Although the transmission system is equipped with capabilities for monitoring and control to minimize outages and understand its vulnerabilities due to certain events, increased investment in faster and more widespread data collection is needed. This investment will allow the intelligence about the system to increase and be "forward thinking" to allow potential remediation efforts to be in place should a disturbance occur. Rerouting of flows with special devices could allow certain lines to be more optimally used. Substation monitoring equipment could provide an early warning of potential failure and minimize prolonged outages. Loss reduction could be a major outcome, to the benefit of the system and environment.

Smart Generation

Generation control to maintain close tolerance on the system frequency in the United States has been the hallmark of the quality of our electrical grid. Maintaining this quality requires significant investment in generation reserves and standby generation. The application of significant amounts of non-dispatchable resources, like wind and solar generation, will increase the cost of maintaining these reserves.

The smart grid, through the ability to control end-use load, could be a major help in minimizing the impacts to the control issues associated with increasing levels of solar and wind resources on the system. Storage devices, such as thermal energy storage and batteries in plug-in hybrid vehicles, could play a major role in lowering the cost of frequency control and generation reserves and allowing better integration of renewable resources.

Smart Communications and Meters

The core of the smart grid is the two-way communications between generation, transmission, distribution and customers. Increased communications capabilities will be required by most utilities to achieve the two-way communications between their operations centers and each of the meters on the system. A variety of approaches are discussed in this guidebook.

Advanced meters will also be needed to implement the smart grid. Although advanced metering infrastructure is the current utility approach, various Internet providers are also developing approaches to help customers manage their consumption. Either approach will provide the customer and the utility more information about the cost and usage of electricity.

As we install increased digital devices that are networked to the utility's computer systems, security will be a major concern. Correct development of firewalls and monitoring systems will be critical to the safeguarding of information and control systems from hackers.

Smart Investments

Where do we go from here? There are several components to the smart grid. Some of these components may already be in play at your utility and can support the evolution of the smart grid. Other utilities are working purposefully on various aspects of the smart grid. Some public power utilities are investing in communication systems to homes, distribution automation, advanced meters, and customer-side devices such as plug-in hybrid electric vehicles, customer-owned generation and other demand response applications. When they all communicate and work together, the smart grid will be born.

Many of the components of the system at the end-user level are yet to be developed. Smarter appliances are being designed with computer intelligence and interconnectivity with the Internet. Home-area networks that will collect and distribute information associated with energy usage are in the development stage.

Development of a business case that identifies the goals, benefits and costs of the smart grid for each

utility is the first step in considering investment in the smart grid. Determining what aspects of the smart grid are already on the system is important. Before moving forward with smart grid investments, each utility must identify sources of funding and develop a repayment plan. Regardless of how the development of the smarter grid evolves, utilities both large and small must be active to meet future demands of consumers.

Smart Grid Concepts Explained

The smart grid means different things to utilities, customers, regulators and vendors. These buzz words infer a "thinking" intelligent grid but mask how much the concept affects power production, delivery and consumption. In a sense, smart grid represents the future of investments made in electric power infrastructure. Traditional investments have been centered around hard assets such as transmission lines, substations and power plants. The smart grid approaches these utility investments from an efficiency viewpoint. It asks the question "How can we get more out of the traditional infrastructure?" Some of the ways people are thinking about smart grid applications and ways utilities can get more by using the smart grid are described in this guide.

Smart grid represents the changing relationship between the utility and the consumer. Traditionally, electric power has been viewed as a linear relationship where generation supplies transmission, which in turn supplies distribution, which then supplies the end consumer. (Figure 1)

Smart grid changes the dynamics among these players. In essence, we have moved the capabilities of generation much closer to the consumer. Today's renewable energy advancements, distributed generation capabilities and energy storage technologies together with the smart grid, enable the user and utility to manipulate consumption and affect the process of supplying demand as never before in electric power history. (Figure 2)

The Value of the Smart Grid

Smart grid will allow utilities to leverage their existing assets to provide reliable and cost-effective energy while opening the system up for the next generation of innovative automation and energy choices for

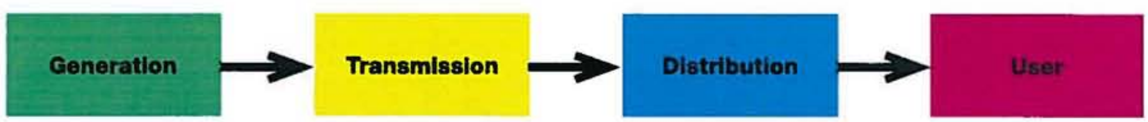


Figure 1: Traditionally, electric power has been viewed as a linear relationship.

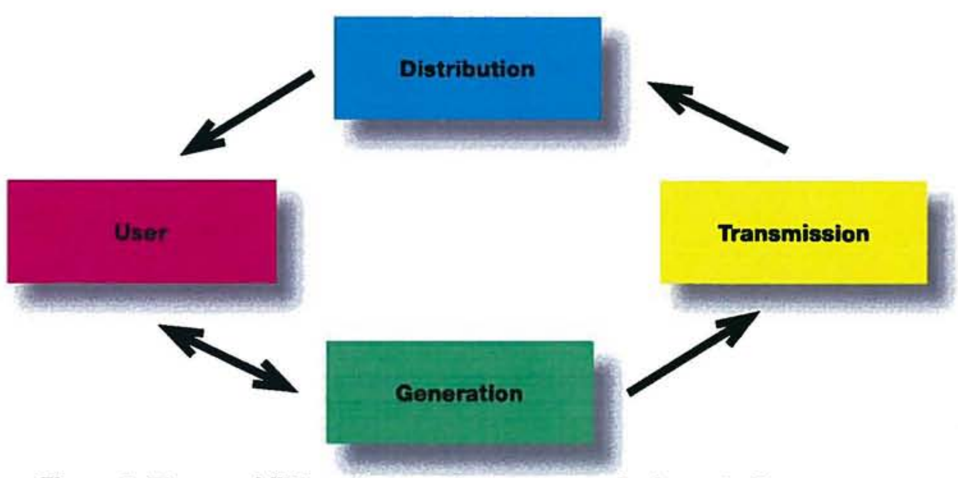


Figure 2: The capabilities of generation move much closer to the consumer.

consumers. Over the next 20 years, the investment in generation, transmission and distribution infrastructure is estimated to be between $1.5 trillion to $2.0 trillion. While funds are invested to improve the existing infrastructure, load growth and clean energy requirements will create an energy deficit over the same time period. A modest 1 percent annual increase in demand would result in a need for approximately 200GW of new capacity over the next 20 years.

The two major differences between the speed of acceptance and impact of the vast improvements made in the phone and information technology sectors via computerization and the changes that can be provided by the smart grid to the electric utility industry are safety and connectivity. The electric utility industry is unique: it has thousands of facilities and thousands of miles of wire lines that require the utmost in safety for the public and for workers to avoid serious injury and death. Safety is the most important consideration when implementing any change in the industry, such as the smart grid. Although "plug and play" may be a great commercial concept in the digital world, utilities have to take a more cautious approach to allowing customers access to the power system.

Also, due to the high cost of alternate feeds, the vast majority of customers on the distribution system do not have more than one connection to the grid. This means that if the grid goes down, power cannot be rerouted to them on parallel circuits. The source circuit has to be reestablished to restore power unless local backup generation is available.

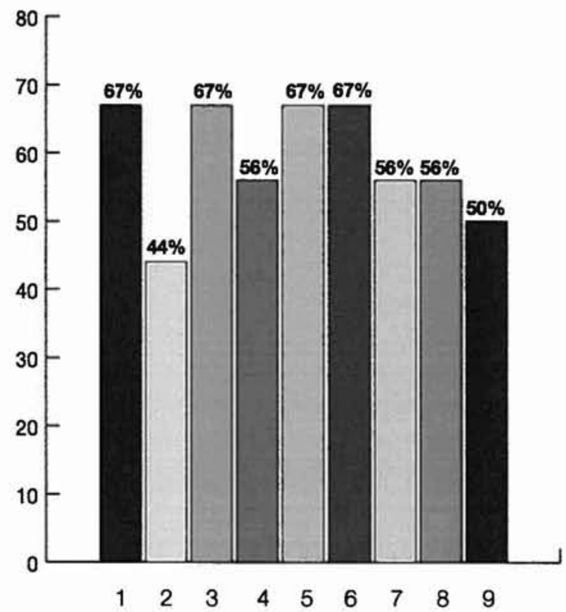
Major objectives for implementing the smart grid to leverage current infrastructure while providing capabilities for innovation:

- Maximize the use and investment of existing grid assets.
- Bring more detailed information about the load and its effect on the system elements into the utility operations.
- Organize and coordinate the capabilities of high load appliances, consumers and distributed generation resources to assist in maintaining high system reliability and reducing customer costs.
- Improve the process of balancing energy supply with real-time demand needs to minimize utility operating costs by bringing more effective load control response into the mix.

Survey Question

Which of the following do you think of as smart grid vs. normal utility operations?

1. AMR/AMI
2. Time of Use Rates
3. Real Time Pricing
4. Distribution Automation
5. Demand Response/Load Control
6. Remote Connect/Disconnect
7. Distributed Generation Integration
8. Condition Based Monitoring
9. Real Time Outage Management



By taking full advantage of smart grid connectivity, utilities can significantly improve their speed of response to any customer need or service disruption. However, worker safety remains paramount and utilities must ensure the enhanced connectivity does not compromise the safety of its employees or customers.

The planning and operation of the system is based on standards issued by the Federal Energy Regulatory Commission (FERC) and implemented by the North American Electric Reliability Corp. (NERC). One of the basic requirements of the planning process is that the system should be unaffected by loss of a single element at its maximum loading level, or what is commonly called a first contingency condition.

To meet the first contingency condition, many elements of the system are operated at their maximum level for only a few hours per year. The smart grid can help provide the ability to monitor normal and emergency ratings so lines and transformers can be operated for more time at their maximum levels without concerns about safety or reducing system life. This will allow utilities to delay upgrades, saving investment funds.

Deployment of the smart grid will enable a greater exchange of information among utility functions. If the promise of the smart grid is to be fully realized, information will need to be shared across all of the utility's divisions. If this is achieved, utilities will have a broader understanding of cost drivers, which will facilitate better management of resources.

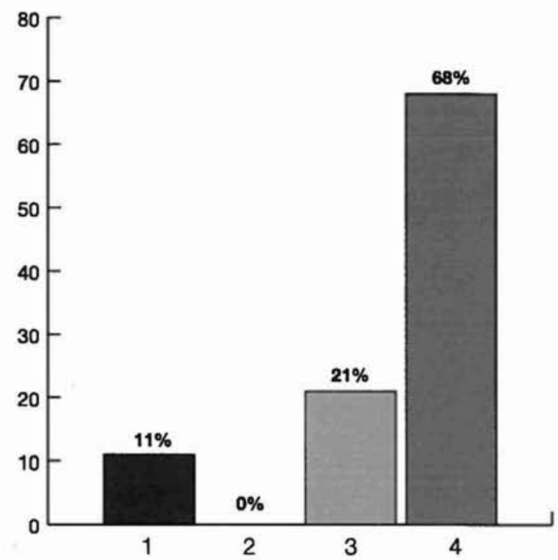
To obtain the complete promise of the smart grid, we will need communications with the smart customer, the smart distribution system, the smart transmission system and the smart generation. The information in the following sections is provided as a broad perspective of the areas where a smart grid could be applied to the industry. All of the discussion is not applicable to all utilities. Some utilities may need to read only the customer and distribution sections. However, there is something for everyone in the application of components of the smart grid.

As seen by the following survey results public power utilities are ready to begin implementation due to their local leadership.

Survey Question

What is the most important driving need for implementing smart grid?

1. State Law
2. PUC/PSC Requirement
3. Local (political) Request
4. Utility Management/Leadership Recommendation



Smart Grid Defined -

Smart Customer Capabilities

Utility customers demand reliable power at the least cost. Public power utilities have delivered on this mission for decades. So how does a utility manager use the smart grid to interact with the customer for them to make smarter energy decisions? One of the main benefits of smart grid initiatives is to provide the customer with information on electric cost and consumption. This information would then allow customers to obtain desired services using an approach that fits their lifestyles and budgets.

In addition to the management of consumption by the customer, the smart grid could provide value-added services from the utility to the customer. These might come from allowing the utility to use the customer load at certain times. It might come from providing incentive to add energy storage technologies that could benefit the system. Customer generation could be used to reduce outages.

For customers to make smart decisions on controlling usage and potential value-added services, information about cost and usage must be communicated between the customer and utility. The sources of this information are energy costs from the utility and usage within the customer facility.

This section of the guide provides a glimpse of the types of customer-related issues that can be considered and the infrastructure that will be required.

Time Varying Rates

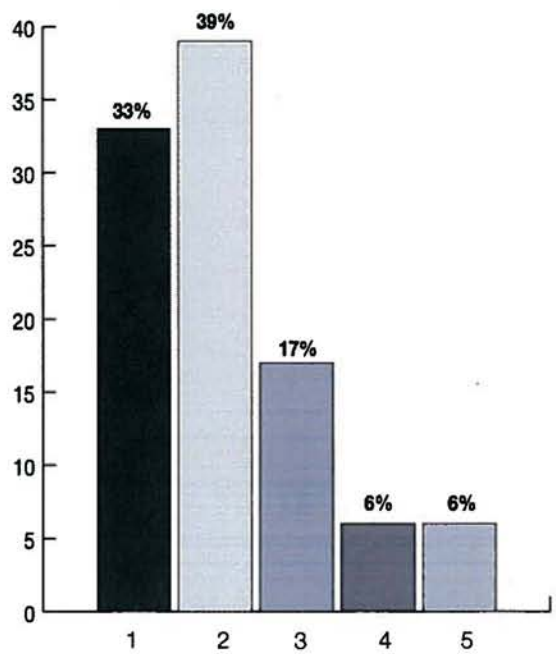
Except for electric energy sold to large industrial and commercial customers, most electric energy is sold on an average cost-per-kWh basis. However, the cost to utilities to produce this power can vary significantly over a 24-hour period, creating a significant disconnect between utilities' supply cost and the rate charged to consumers. Consequently, the majority of customers who pay average cost rates do not have financial incentive to modify their consumption patterns regardless of hourly changes in supply costs.

Time-of-use rates have been offered by some utilities to consumers to spur motivation to change their usage patterns and conserve energy during high price periods. These structures typically offer rates in on and off peak periods or perhaps vary by season of the year.

Beyond time-of-use rates is dynamic pricing. Dynamic pricing reflects the hour to hour changes in utility costs. Price variability can be seen by looking at a hot summer day in the Midwest Independent System

Will the promise of smart grid be dependent on time of use/real -time rates communicated to all customers?

1. Strongly agree
2. Agree
3. No Opinion
4. Disagree
5. Strongly Disagree



Transmission Operator market. Figure 3 shows pricing taken from the First Energy Hub in the Midwest ISO market for July 2, 2008. Prices vary by a factor of seven to one for this day.

If consumers were presented with prices that varied during the day, would they change consumption habits? Would they turn off other appliances besides the air conditioner to reduce costs? If electricity got expensive enough, would they turn off the air conditioner? Or, would they put in a device that allowed them to better control their lifestyle at a lower cost? How involved would the typical consumer want to be in managing costs versus usage?

Response to price signals can be passive in nature, as in the typical parental response of "Turn the lights off!" to installation of motion sensors that make lighting control automatic. It can take the form of a simple manual adjustment of a thermostat based on building occupancy or a sophisticated programmable thermostat. Price signals can induce the consumer to invest in more energy efficient appliances or buildings to minimize use during high price periods. Price differentials can promote shifting loads to lower cost time periods.

When consumers see price information that parallels that seen by utilities, consumers will be able to make sound decisions about how they use electricity. These decisions will affect the utility's power supply costs.

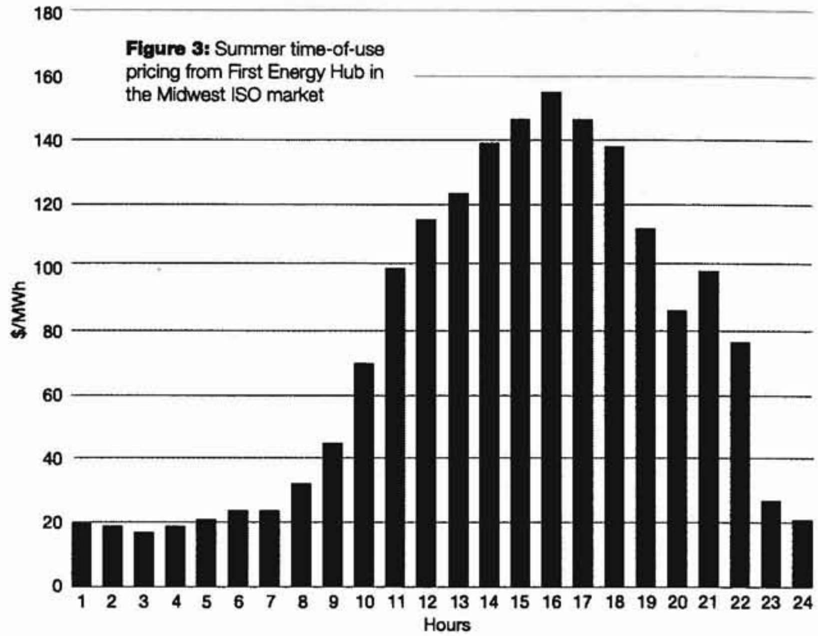


Figure 3: Summer time-of-use pricing from First Energy Hub in the Midwest ISO market

The pricing for a winter day can be seen in Figure 4. Prices for this day vary by a factor of three to one.

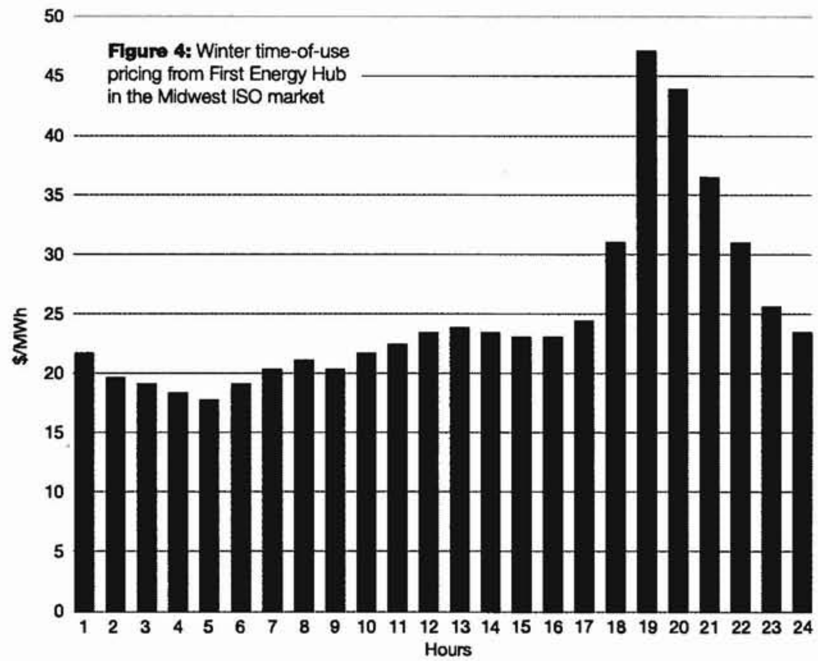


Figure 4: Winter time-of-use pricing from First Energy Hub in the Midwest ISO market

Is it necessary for a utility to implement time-varying rates to achieve some of these load-modifying benefits? Results from the Olympic Peninsula Project Study by Pacific Northwest National Laboratory indicate that consumers can reduce consumption by 15 percent with time-of-use information.[1] In this project, customers had access via the Internet to dynamic pricing and consumption information. Other Internet-based information is provided through "dashboards" created to provide consumers consumption and pricing information.[2] Numerous other studies have

[1] GridWise Demonstration Project fast facts, Pacific Northwest National Library

[2] www.luciddesigngroup.com

similarly indicated that consumers will respond to dynamic pricing to manage their consumption.[5]

Widespread application of time-of-use and dynamic rates is yet to be seen. Movement away from average pricing to time-varying pricing will take time as utilities and customers become comfortable with the approach and can implement them without significant negative impacts on customer bills.

Thermal Storage

Energy for heating and cooling of buildings is typically needed during the coldest or hottest part of the day, when the most demand is on generating units. What if you could store hot or cold energy during times when the demand (and cost of energy) was low and release it during the high demand and cost times? Thermal storage allows you to do just that. Special bricks are used to store heat in heating systems while ice is used to store cold for air conditioning systems.

Commercial and industrial thermal storage systems have been in operation for years to take advantage of lower night time prices. Residential thermal storage systems for heat have been used since the 1980s in the Midwest, giving utilities control over hundreds of MW of residential load. Ice storage systems for small commercial and residential applications are also becoming available. Dynamic or time-of-use pricing is necessary to realize the economic benefits of these systems.

Installation of thermal storage at customer sites could also benefit the utility. This use is described further in the Smart Generation section of this guide.

Demand Response

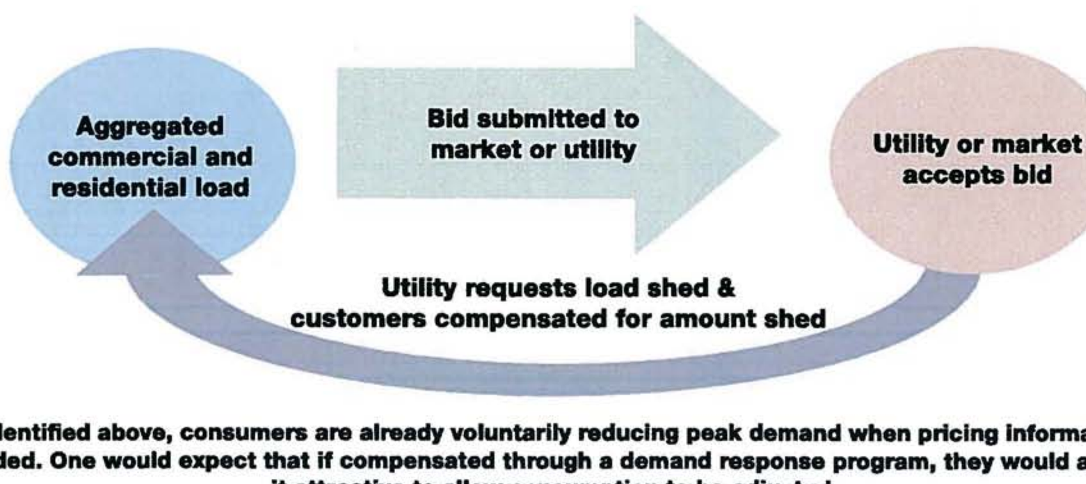
Another customer choice might be for the consumer to allow load to be shut off if it was compensated sufficiently. Periods of high load demand (peak periods) typically last for only a few hours per day. The generation used to meet the peak load needs to be able to be brought on line quickly and then taken off line just as quickly when the demand drops. The generating units capable of meeting peak demands are typically the most expensive units on the system to operate. If the customer can be enticed to curtail load during peak times, the higher-cost generation is not used and the energy price declines for the utility and the customer.

This enticement can come through a demand response program. The demand response program provides an opportunity for the customer to be compensated for reducing load during peak pricing times. Some independently operated wholesale electricity markets, such as the PJM, offer formal demand response programs. These programs allow consumers to bid portions of their load into the market and in return are compensated if their bid is accepted. In some areas, load aggregators collect small consumers into pools that are then bid into the market.

The smart grid devices provide information to the consumer and the utility about the value and success of demand response programs. It allows utilities to know what load is operating and therefore, what demand response is needed.

Home Area Networks (HAN) and In-Home Displays (IHD)

So how do the utility and consumer know what the consumption and price looks like at the consumer



As identified above, consumers are already voluntarily reducing peak demand when pricing information is provided. One would expect that if compensated through a demand response program, they would also find it attractive to allow consumption to be adjusted.

[5] Fortnightly, March 2009, pages 26-37

level? The integration of the customer into the smart grid requires two-way communication between the utility and the customer. It requires electricity cost and usage information to flow to the consumer. It requires information about consumption to flow back to the utility. This transfer can be accomplished through a variety of options.

One of these is the smart meter. A variety of smart meters are available to the utility. Common attributes of smart meters include:

- the ability to display consumption inside the consumer's facility.
- feedback to the utility about power quality at the meter location.
- detailed consumption history.
- remote connect and disconnect.

Many utilities are installing smart meters via their advanced metering infrastructure (AMI) programs.

New home area networks (HAN) are being developed that allow consumers to monitor and control individual appliances. Smart meters can interface with these HANs. Information can also flow between the utility and the consumer via the Internet. Several major companies are working on Internet-based smart grid applications. Interface of the HANs with the Internet is also a potential.

The highest valued energy usage information identified by customers, based on early results, is the ability for the customer to know the current cost of electricity.[4] Sixty-nine percent of consumers have expressed "high interest" in using display devices to lower their energy costs.[5] To conserve energy or reduce peak demand charges, over a third of PG&E's SmartRate program participants chose to shut off, curtail or shift use of their air conditioners, appliances and lights on high-energy-cost days.

Beyond the ability of customers to manage consumption in response to price variations, smart grid technologies offer utilities opportunities to control customer devices to manage system load. Although load management and control has been applied to customer loads since the late 1970s, the smart grid offers opportunities to expand the number and type of devices controlled and how they are controlled. Whether consumers will allow widespread control of their appliances remains to be seen. This could become an expanded source of credit to consumers as load control becomes more valued by the utility, increasing customer willingness to participate in control programs.

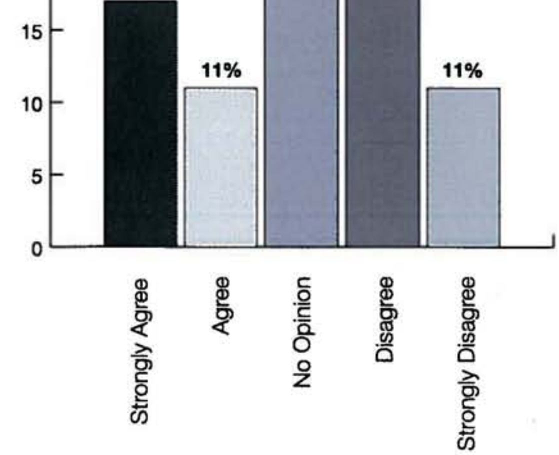
Two-way communications flow between the utility and the customer can be provided by:

- A utility-furnished wide-area network that extends an existing AMI deployment into the home via Zigbee-based protocols.
- Existing Internet service provider broadband connection, such as cable modem, DSL or some other always-connected network.

Plug-in Hybrid Electric Vehicles

Considerable public media attention has been devoted to the anticipated development of the plug-in hybrid vehicle. When it does appear on the roads in large numbers, the Plug-in Hybrid Electric Vehicle (PHEV)

Will the promise of smart grid be dependent on widespread adoption of PHEV or other energy storage technologies?



[4] Energy Insights, December 2007, Ryan & Burstein #EI210074
[5] PG&E's Home Area Network (HAN) Overview, January 2009

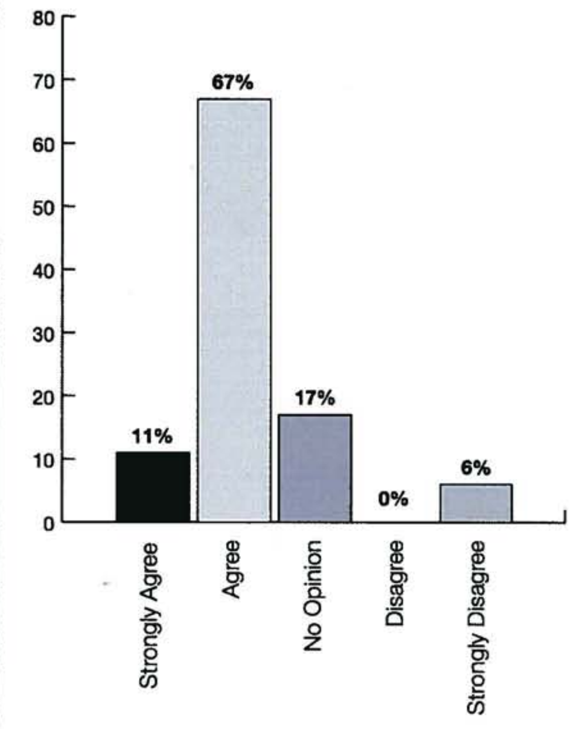
will be one of the more challenging loads for utilities to serve: Charge during the day while at work or shopping? Charge at night at your residence or operation center? Should the utility control the charge? Will the car be smart enough to charge during low price periods? Where will the grid be most impacted?

A significant amount of research is currently being performed on the charging protocols for the PHEV and the results on the grid. Numerous national labs, including Oak Ridge National Laboratory, are researching the impacts of plug-in hybrid vehicles on the grids. Charging the vehicles will have the greatest impact on distribution circuits, with less impact on the transmission system. For instance, in areas where numerous homes are connected to a single distribution transformer, the distribution system could encounter significant challenges in meeting charging demand if each family has one or two PHEVs. Charge management will be necessary so utilities will not have to rebuild significant portions of primary and secondary distribution service.

The smart grid will have a major role in managing the effects charging will have on the system from the distribution system all the way to the generator. Vehicle location indicators, charge levels, and other information may be needed to minimize the PHEV impacts to the utility and customer.

Figure 5 shows the projection of hybrid vehicles developed by the Energy Information Administration of the DOE. The figure does not show a significant amount of vehicles prior to 2030. The recent changes in the auto industry may change these projections. When PHEVs will achieve significant penetration is uncertain. However, it is certain that the smart grid will be a major benefit, if not a necessity, to the integration of the cars to the electric system.

Will your estimate of the timeline before PHEV will be deployed and be a load impact on your system?



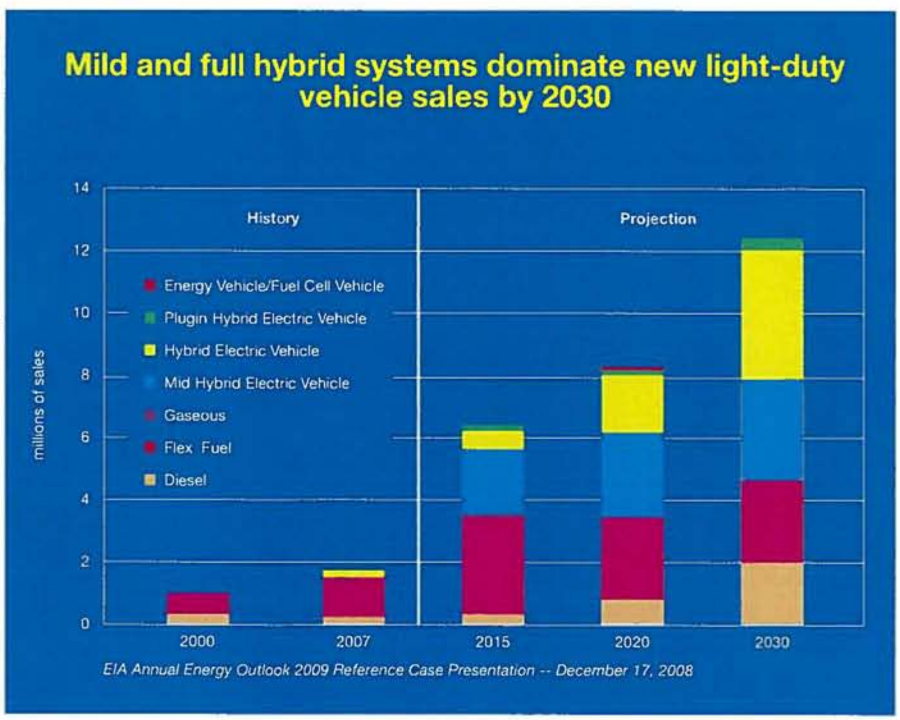


Figure 5: DOE Projection of Hybrid Vehicles

Smart Grid Defined -

Smart Distribution Capabilities

Investment in electric distribution systems over the next 20 years is expected to exceed several billion dollars per year. New feeders, substations and switching equipment will be needed to provide power to new end-use customers. The use of the smart grid can provide a means to minimize this investment and make the most out of the dollars that are spent.

Distribution systems are designed to provide reliable power with proper voltage to customers at a variety of peak and off-peak conditions. The systems have typically been designed to provide a single source of power to an end-use customer. When an interruption occurs at one point on the system, all load downstream from that point is removed from the distribution system. Smart grid devices can be used to minimize the impact of this common "radial" design and enhance reliability.

Other uses for the smart grid on the distribution system include:

- Improved capital planning and system improvement
- Loss reduction
- Better customer service
- Enhanced outage recovery through distribution automation and "micro-grids"
- Optimize crew dispatch

In urban areas where distribution feeders are looped, smart grid devices can isolate problem areas and restore service to the majority of customers through automatic transfer to another feeder.

The development of more distributed generation on the system, through local back-up generators, CHP units and renewable energy sources, allows "micro-grids" to be established. A micro-grid is a small island of load that can be served by any local distributed generation. The smart grid devices could possibly manage the loads on these micro-grids to maximize their generation contribution.

Distributed Generation (DG)

Distributed generation is developing rapidly on many customer systems. Various forms of distributed generation currently exist on the grid. These can take the form of individual back-up engine generator sets at commercial buildings, hospitals, water treatment plants and small residential units that are only used to produce electricity. They could be renewable, such as solar photovoltaic; or they could be large industrial cogeneration units that produce both electricity and steam.

A combined heat and power (CHP) facility is another form of distributed generation. CHP systems are used in commercial and industrial facilities to produce electricity through a combustion turbine or other generator and use the waste heat in another process, such as chillers. CHP systems using natural gas are capable of overall efficiencies of over 80 percent.

Residential micro-combined heat and power units are also available and could become popular in certain parts of the country. These units have a small (approximately 1-kW) natural gas-fired generator with a heat recovery system on its exhaust that is used to heat air for a forced-air furnace or water for a hydronic heating system. APPA's DEED (Demonstration of Energy-Efficient Developments) program has awarded grant money to support and evaluate the installation of such units in Massachusetts.

The smart grid can allow for the proper monitoring and control of these units to maximize their potential for both the customer and the utility. This has to be accomplished while maintaining the proper interconnection and safety standards.

Warm Air Micro-CHP System

With assistance from a DEED grant, Braintree Electric Light Department evaluated the features of a residential home heating system that generates electric power as a byproduct of normal operation. KeySpan Home Energy Services installed five Climate Energy Warm Air Micro-CHP Systems, powered by Honda, in residences served by BELD. The Micro-CHP Systems replaced existing warm air furnaces and the Honda MCHP was connected directly to the home's electrical panel via a 240-volt dedicated circuit.

The five Micro-CHP Systems operated for more than 18,000 hours, producing more than 18,000 kWh of electric power. This power production was achieved with about the same amount of fuel consumed by the previous home furnace. The higher efficiency of the Micro-CHP System offsets the extra fuel used to generate power.

The five Micro-CHP Systems provided about 4,000 kWh of green distributed generation in a year. The study also indicated a 4,500 lb. reduction of CO_2, thereby significantly reducing each homeowner's carbon footprint.

Asset Optimization

Distribution systems consist of overhead and underground distribution lines, substation transformers, distribution transformers, switches, voltage regulators, reclosers, shunt capacitors and a host of other devices. These devices number in the thousands for a small utility and millions for a large one. Monitoring the status of these devices, controlling the devices and making sure they are working properly is primarily done through manual means now, but doing this automatically could improve power quality and reliability and extend the life of devices by identifying problem areas before failures occurred.

For instance, shunt capacitors have fuse links for protection. If the fuse blows, it is difficult to detect. Quite often it is identified by a line crew driving by in a truck. The capacitors can be out for some time before they are repaired. In the meantime, voltage along the feeder may have suffered. A smart grid device would allow voltage monitoring at each end-use customer via an advanced meter. This would alert the utility to a malfunction in voltage regulation equipment and repair crews could be dispatched with relative accuracy to the location of the problem.

Other smart grid technologies for distribution systems would enable utilities to perform feeder analyses for load redistribution, deploy field devices to detect circuit problems, and use automated switches to transfer customers to minimize the effect of system disturbances.

Distribution Automation

Distribution automation (DA) is the application of remotely controlled switching and monitoring devices to distribution feeders. These devices communicate to a control room to give operators better intelligence about the system and more control over switching it. Certain devices can communicate with each other and perform automatic switching. An example of DA would be installation of fault locators on feeders at all taps and junctions so a fault's location could be easily identified. Then, with remote-controlled switching installed, the operator could isolate the fault and return the healthy portions of the system to service. The opportunities to improve system performance with DA include:

- Minimizing crew dispatch if problems can be resolved via control system
- Closer pinpointing of problems, thus enabling more efficient dispatch of repair crews
- Reduced outage times
- Decreased response times
- Better power quality
- Remote transfer of power to adjacent substations during transformer outages or maintenance
- Optimization of assets and loss reduction
- Better information for system planning
- Establishing micro-grids
- More precise voltage control for energy conservation

Distributed automation is being used and expanded in:

- Anaheim, CA- uses feed sectionalizing on all of its system
- Nashville, TN- just starting to deploy
- Naperville, IL- currently on 70% of feeders

Load Management

Utilities have pursued load management for well over 30 years. Typical systems were one-way with a broadcast control message to thousands of devices simultaneously. The main use was to reduce peak loading on the electric system. Customer loads would be controlled for a few hours per year to reduce system peaks. For instance, to achieve a 10 percent reduction in peak demand, one municipal utility would have to control load only across 93 hours per year. Participating customers typically received a credit on their utility bills.

Summer-peaking utilities usually controlled water heaters and air conditioners. Winter-peaking utilities have controlled heat-storage devices and dual-fuel heating systems. The actual kW amounts controlled for the device depend on the weather and natural diversity of the appliances on the system. Load management has the potential to be expanded into more appliances as lower cost switching capability is integrated into the appliances. For instance, low-cost switching capability afforded through home area networks will facilitate control of future smart appliances like electric clothes dryers and refrigerators.

Another load management option is to reduce voltage on the feeder, which reduces the load on the system. Since the advanced meters deployed with the smart grid can monitor voltage at each end-use location, maximum load reduction can be achieved while maintaining power quality along the feeder.

To achieve the maximum benefits for the utility from asset management on the distribution system, loads must be controlled on an individual basis. For instance, it will be necessary to have the ability to limit the maximum demand within a home between the air conditioner, oven, clothes dryer and plug-in hybrid to prevent overloading of distribution transformers and feeders when PHEVs become popular.

Distributed Generation Management

The prevalence of distributed generation (DG) on a system provides an opportunity to control the generation to maximize its capabilities to benefit the system.

Two types of DG are prevalent on the system. Traditional engine generators or combustion turbine-type generation has been installed for years at various commercial installations, such as hospitals. Recently, residential customers have installed generators to provide back-up power for outages from hurricanes and other storms.

The second type of DG includes renewable energy sources such as solar and wind. The use of solar systems is most prevalent in California, with New Jersey also adding significant units. Large utility-class grid-connected wind generation capacity grew by 50 percent in 2008.[6] Texas, Iowa and California lead the nation in installed capacity.[7] Smaller residential units are expected to be added to the distribution system. The monitoring and control of the interconnection and power flow will be a major challenge if renewable energy sources become widespread. Power flow must be synchronized and system protection maintained for grid reliability and worker safety.

The smart grid can manage distributed generation and enable the utility's capability to control the generation remotely. This utility control can be used to assist with loss reductions, postpone feeder capacity upgrades, assist during substation outages, and manage micro-grid activity.

Micro-grids are an interesting concept for municipal utilities. Most cities and small towns with their own municipal utility have local generation back-up if their connection to the grid fails. The micro-grid takes this a step further with generation located at end-use consumers, which enables a portion of the load to be maintained if the distribution system fails.

Micro-grids can be developed for:

- College campuses
- Hospitals
- Downtown areas
- Commercial complexes
- Subdivisions
- Industrial areas

Transformer Management

On the distribution system, two types of transformers are most common. These are the main power distribution transformers located in the substations that step down power from the transmission level to the distribution level and the transformers that step down from the distribution level to the end-user level.

The main power transformers are rated in tens of megawatts. They are located at primary substations throughout the system and are connected to various distribution feeders that carry power to the end-user transformers. These transformers are typically oil-filled units. They are often larger than necessary for their normal load so they can provide capacity to the system should another transformer on the system fail.

[6] www.awea.org
[7] www.awea.org

Distribution transformers for end-users are typically rated in kilowatts for residential and small commercial applications with higher ratings for larger commercial and industrial customers. These transformers can be pole-mounted or pad-mounted. The units for residential applications are typically designed so one transformer feeds a number of residences. The sizing of the transformer is based on the types of loads in the homes. Newer subdivisions may see only one or two homes on a transformer. Older residential subdivisions could have up to 10 to 12 homes per transformer.

Residential transformers normally have low load factors due to residential consumption patterns, incremental property development and the subsequent location of facilities. The smart grid will allow enhanced residential transformer use by improving the ability to monitor and control household devices and their load, which in turn improves the design and planning of facilities.

Plug-in hybrid electric vehicles represent the major projected load change at the residential end-use level. Widespread application of these loads without proper management could have a significant impact on the utilities' system, requiring considerable infrastructure investment, especially at the distribution level. Widespread acceptance of PHEVs could be hindered if smart grid technologies are not in place to monitor and manage the load.

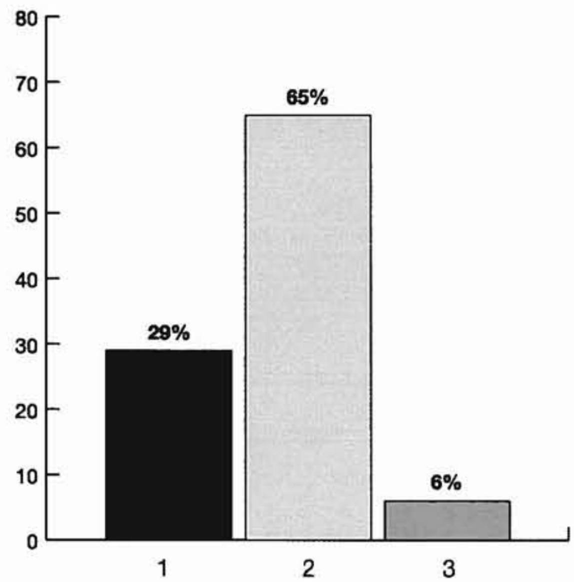
Loss Minimization

The U.S. Department of Energy estimates that average system losses are approximately 7 percent for both transmission and distribution systems. These losses can be broken down into two types: no-load losses and load losses. No-load losses occur continuously when the system is energized and smart grid applications will not provide much for potential savings. However, load losses are caused by the electrical current flowing through the transformers and conductors (wires, cable, etc.), and the losses are expelled as heat. An additional form of load loss is electricity theft. Sixty percent of the T&D system losses can be attributed to load losses.

Based on current national usage, each 1 percent loss represents about 5,000 MW of generation operating each hour of the year. This is equivalent to three modern nuclear plants or about six new coal plants. Management of customer loading on the system through the smart grid would allow peak loading to be reduced. Since the load losses are proportional to the square of the current, reducing the peak current by 10 percent would reduce peak load losses by 19 percent. Load loss reduction can occur through cycling appliances off, using thermal storage to shift peak loads to a lower load period, use of voltage reduction and a variety of other methods.

What were your annual losses in 2008?

1. Less than 5%
2. 5% to 10%
3. Greater than 10%



At the distribution level, the smart grid can reduce line losses by optimizing feeder configurations and minimizing the distance power flows. Better balancing of the phase currents can also reduce losses. The smart control of capacitors reduces current levels and losses. Intelligent meters with two-way communication enables utilities to better use transformer and cable capacity, which can reduce losses at the distribution and service level.

Load Research and Meter Data Management

Any time a rate change or other costs impact customer bills, complaints about the bills start rolling in. The smart grid, through AMI and the HAN, allows a utility to better examine and explain a customer's usage and determine what factors are affecting their bills. The more advanced HAN systems will allow metering by appliance.

Other metering services can be provided by monitoring the voltage at the customer premises. High and low voltages and other power quality issues can be monitored like an open neutral condition. An open neutral can cause wide fluctuations from the standard 120 voltage. If the utility is aware of the variances, it can make repairs and act quickly to minimize damage to household equipment and appliances.

Remote Connect and Disconnect

In locations with a highly transient customer base, such as university towns, remote connections and disconnections can significantly reduce the amount of time and work force required to change service status. The smart grid can also limit service to a predetermined amount of usage. This can be provided by pay-as-you-go cards and meters or similar means.

The remote connect and disconnect ability not only saves resources but also saves turnaround time for new occupants and reduces safety concerns for utility employees (dogs, inclement weather, crime, etc.).

Outage Management, Rapid Outage Identification, System Restoration

Utilities, to a large extent, still rely on customers to call in and report an outage. Substation breaker operations are monitored, but most protective devices on the distribution system are not individually monitored. However, with AMI in place, utilities can readily identify problem areas through intelligence, which improves utility crews' response times considerably. Distribution automation in concert with AMI enables utilities to dispatch crews to a problem area after automated switching has isolated the problem and restored service to adjacent areas.

Intelligent Municipal Applications

The smart grid can also be useful to local governments. Additional services could be used to assist municipal governments through the communications systems deployed for smart grid applications. Faster identification of traffic light malfunctions–security light monitoring–could be incorporated into the smart grid. Video cameras on major intersections could be used to remotely control traffic signals for more optimum traffic flow. Assistance to emergency vehicles could also be provided. For instance, with remote connect and disconnect, the power could be turned off before the fire trucks arrived at a fire. Also, emergency medical teams could be apprised of any power outages with people having critical life support systems.

Customer Benefits

Another use of the smart grid is to improve customer service without expanding the work force. Being able to diagnose outages remotely, perform services without a service call, describe differences in usage and a host of other issues that utilities currently deal with can all be provided via the smart grid. Following are a few ideas.

- More efficient work force deployment through customer level outage data
- Faster response to connection and disconnection requests
- Individual customer power quality information
- Individual detailed usage data to better explain customer bills
- Enhanced customer information systems tied to geographic location of customer

Integrated Utility Asset Visualization

Utilities are increasingly seeing the benefit of enhancing the ability to visualize their systems, facilities and equipment from a common database or central information system. They can review a variety of graphic representations including maps, drawings, photos, illustrations and the associated descriptions.

Utilities can simultaneously review this content in the office and in the field in an updated or real-time basis. Knowing this information is reliable up to a specific date allows utility personnel to make more accurate decisions considering any present time planning, design or work under way. This visualization can be extended to customers or the public with great benefit.

Outage management systems deployed in:

- Nashville, TN - tied to geographic information system. As customers call in, their information is automatically tied to location and a trouble ticket created by the system. Results in efficient deployment of work crews.
- Princeton, IL - using computer relays on feeders to identify fault locations and report automatically to dispatch.

For example, some utilities are providing customers with system mapping on the Internet that shows their outage areas and how their restoration efforts are progressing during storms. Public access to utility visualization systems can also be valuable during public planning sessions for facility routing or right-of-way considerations.

The smart grid and its expansive communications capability allows utilities, customers and the public to graphically view information about assets and infrastructure that greatly enhances decision-making and overall operational efficiency. The ability to monitor facilities also enhances security and worker safety.

Mobile Field Work Management (MFWM)

Probably the greatest advancement in utility worker-productivity in the last decade can be attributed to mobile dispatch and automated work management systems. The planning and standardizing of stepped work units that can be viewed in mobile display units (MDUs) and reported on in the field has greatly improved work force efficiency. Job orders are strategically assigned to reduce travel time requirements. Customer outage durations have also been improved as service personnel are tracked and redeployed to hasten restoration. The smart grid monitors system performance and optimizes the best response, which is multifaceted, including field personnel and system operations (reporting, dispatch, switching and record-keeping).

The following lists some fundamental smart grid benefits associated with mobile field work management:

- Optimized scheduling of daily work orders considering available personnel and type of work
- Automated dispatch capability considering location, shortest route, type of work, cost of service, customer priority and time
- MDUs providing customer information, mapping and probable outage locations
- MDUs providing attribute information about assets, facilities and terrain (pictures, condition status, etc.)
- GPS units tracking specific vehicles, which increases worker safety if assistance is needed

Smart Grid Defined -

Smart Transmission Capabilities

The transmission system is used to deliver the power from the large, central station generation or the remote renewable generation, such as wind, to the distribution system. The transmission system includes the large power transformers, lines, breakers and switches, shunt devices for voltage control, series capacitors and phase shifters for power flow modification. New devices such as variable frequency transformers and flexible AC transmission system devices are also being added for power flow and voltage support. Large High Voltage Direct Current (HVDC) systems are currently operating on the grid, and more are being considered to move large amounts of renewable energy to load centers.

The transmission system is monitored more closely than most distribution systems through Supervisory Control and Data Acquisition (SCADA) systems and the modern generation of solid-state relays being deployed. These systems monitor switch and breaker status, relay targets and settings, magnitudes of voltage, frequency and power flow at all substations. Often, security video is also included from substations.

The smart grid extends the use of traditional SCADA systems to monitor and control more of the transmission system, including enhanced integration of the data for better analysis and planning.

New monitoring systems are being developed to allow more precise measurements of system capabilities. Devices that monitor the line temperature and the resultant sag of a line, for instance, can be deployed so a transmission line can be used to its full capabilities based on the limitations of sag and conductor temperatures. This allows a dynamic rating of the line to be considered with real-time loading data rather than a static rating with a projected loading.

The North American SynchroPhasor Initiative is a nationwide program to enhance grid monitoring. The objective of the Initiative is to increase the types of information captured from the transmission grid to allow a better estimation of the stability of the grid. Current information sent over the typical SCADA system is acquired more slowly than SynchroPhasor data. SCADA information is not time-tagged to allow the information to be lined up with other data within a utility or between utilities. The phasor data will be brought in over 60 times more frequently than SCADA information and time-tagged to allow the analysis on a time-sequential basis. The improvement in the quality of the data is critical for the grid to have automatic predictive switching capability.

Following are comparisons between the Phasor and traditional SCADA data. (Reference Enhanced Wide-Area Visibility: Finding Value in Phasor Measurement, Floyd Galvan, PE, Energy Corporation, POWER-WORLD USERS GROUP MEETING, Austin, TX June 2005.)

EIPP Phasor data:

- Refresh rate 30 samples per second
- All data points time tagged and easy to "line up" for input to state estimator, operator display or planning study
- Compatible with modern communication technology
- Enables action response to system dynamics
- Prelude to automatic switching systems

SCADA data:

- Refresh rate 2-5 seconds
- Some data points are newer than others - no way to tell the diference which leads to state estimator inaccuracy and uncertainty about what is "real"
- Relies on legacy communication technology, i.e. does not take advantage of newer comm. networks
- Enables action in response to system statics

The transmission system also can have multiple parties monitoring it. For instance, in locations with an Independent System Operator (ISO), the transmission system can be monitored by the transmission owner, the ISO and the reliability coordinator. With information available on a time-tagged basis, these parties can make better decisions to improve grid performance. Full implementation of the SynchroPhasor type system is several years in the future.

Remedial Action Schemes

Better intelligence from a smart grid could also assist operations in Remedial Action Schemes (RAS). An RAS is typically employed on a system to avoid or defer the investment in new system elements that would correct a problem that may occur during a rare outage on the system. An RAS is commonly developed due to a system problem that occurs during an outage of a system element. When the element is removed, either through an automatic protection scheme or for maintenance, the remaining system can be placed in a more fragile operating situation. System reconfigurations or generation re-dispatch may be necessary through the RAS to move the system to a more stable operating point.

RAS have typically been implemented on a case-by-case basis. The ability to bring in other system operating parameters when RAS is triggered has not always been available. By bringing in these other parameters, such as dynamic ratings, the RAS may not need to be implemented.

RAS are also typically hard-wired in to the system. Relay settings may have to be adjusted if the scheme is changed. This requires crews to be dispatched to substations. The smart grid can make the RAS dynamic, with adjustments to the scheme made remotely from central dispatch.

The use of the phasor information could provide intelligence to the smart grid that would allow predictive actions based on the existing configuration of the system and loading levels of the elements. Actions necessary should outages occur could be analyzed and the most vulnerable conditions could be corrected through control of generation, flexible AC transmission system (FACTS) devices or load.

Substation Automation

Most utilities have installed SCADA systems that allow remote monitoring and control of their transmission substations. These systems allow utilities to avoid sending crews out for routine issues such as:

- Monitoring condition of equipment
- Performing certain switching operations
- Activating backup devices

Service restoration can be attempted under certain conditions via the SCADA system prior to dispatching a line crew. Advanced products for automating substation functions are being developed for replacement of the older SCADA systems. These products provide local algorithms for such things as voltage control and load shedding.

Condition-Based Monitoring and Asset Management

An early warning sign of a problem with an asset is critical to minimizing outages. Catastrophic failure of oil-filled transformers can cause massive destruction to substations, resulting in lengthy outages. Detection of faulty connections can significantly reduce the probability of lengthy outages.

Asset Management systems are being upgraded. Examples are in:

- Naperville, IL- Moving from information being isolated by department to enterprise wide access for information. Expanding from current conditioned based monitoring for 20% of assets to system wide.
- Princeton, IL- Investigating a pilot condition based monitoring system using existing SCADA system.

Moving away from interval or usage-based maintenance procedures to real-time, condition-based monitoring allows a utility to really understand the condition of the asset. For instance, when a breaker opens due to a fault on the system, this operation causes the contacts of the breaker to wear down. Smart grid technology allows utilities to measure the actual condition of the contacts to determine if maintenance is required versus projecting the need for maintenance based on the number of breaker operations.

More advanced transformer monitoring is being deployed. One system, the Transformer Oil Analysis and Notification (TOAN) system developed by Arizona Public Service, uses an advanced statistical methodology to predict the status of the transformer using advanced real-time oil analysis. This type of analysis can be used to predict the condition of a transformer and remove it from service prior to a catastrophic failure. Better temperature monitoring of the large power transformers also allows better management of the life expectancy due to loading.

Other critical systems that can be monitored for predictive maintenance include:

- Station batteries
- Circuit breakers
- Backup generators
- Tap changers

The use of real time condition-based monitoring allows a utility to defer capital expenditures, reduce maintenance costs and increase reliability.

Smart Grid Defined -

Smart Generation Capabilities

Utilities are expected to provide high standards of power quality and reliability. Power quality is maintained by keeping voltage and frequency within designated tolerance levels at the end-use device. Customers measure reliability by the availability of power. Smart generation ensures power quality and holds sufficient capacity in reserve to make sure power is always available to the grid.

Reserves enable utilities to respond instantaneously to system changes. Standby units are held in reserve to be used when generating capacity is lost or load increases unexpectedly. Increased variability of loads and generation sources, such as wind, increase the level of reserves needed. Reserve margins are established by NERC regulations.

Reliability Reserve Margins

In the United States, it is common for utilities to maintain generation reliability reserve margins of between 12 and 15 percent of peak load. The U.S. electrical system has a demand of about 800 GW. For a 12 percent reserve margin, 96 GW of generation would be required in reserve for outages. At a conservative capital cost of $1,000 per kW, this equates to roughly $96 billion for generation reserves.

Regulations allow interruptible load to be counted toward the reserve margin requirement. The use of interruptible load to provide this reserve margin would release generating capacity to meet future load growth. A component of the smart grid will be to allow a clear understanding of where load is available for control and how much load could be managed to maintain the expected power system performance. This load could then displace generation being held for regulatory reserves. Load growth in the United States has historically been around 1 to 2 percent per year for the past 40 years. Substituting load control for the regulatory reserve source could provide several years where no additional generation capacity would be needed.

Several benefits would be derived from Smart Generation. These include:

- Reduced use of natural gas fired generation for regulation.
- Reduced maintenance impacts to units from frequent cycling.
- More efficient operation of the generation.
- Reduced amount of generation capacity required for all types of reserves.

Operating Reserve Margins

Another component of reserve generation is for operating reserves. Spinning reserves are on line and connected to the system, available to instantaneously respond to load swings and capacity disruptions. These spinning reserves are spread across the generation that is on-line. The operating generators share in picking up the lost capacity when a generator trips. Reserving this space in the operating units can require some units to operate at less than optimal efficiency.

The amount of on-line operating reserves needed is approximately three percent of the load. This equates to about 24 GW of generation being held in reserve across the United States during peak times. The better knowledge of load available for control via the smart grid would allow some of this generation to be released for meeting load more efficiently or to be taken off-line entirely.

The other type of operating reserve is the ready or non-spinning reserve. This reserve is met by generating units that can be started and brought up to load within 10 minutes. The level of this reserve is also approximately 3 percent of load or about 24 GW at peak load conditions. The smart grid will be able to remove the need for some of this capacity with controllable load.

The smart grid is the key to integrating renewable energy:

- Optimizing use of utility and customer storage devices.
- Maximizing benefits of charging PHEV with renewable energy.
- Relief of "too much of a good thing" when excess renewable energy is available.

Renewable Generation Optimization

The addition of renewable energy into the electric grid is on the increase. In 2008, the United States added the most wind generation of any country. Large solar plants were commissioned. Utilities on the east and west coast added photovoltaic panels by the thousands. Wisconsin announced an initiative for its investor-owned utilities to add solar panels. FERC is licensing run-of-river, small hydro units. Utilities in Colorado and Florida have announced plans to install "the world's largest" photovoltaic systems.

These renewable resources are not dispatchable. Their output is on the grid when the wind blows, the sun shines or the water flows. Renewable generation capacity must be backed up with different generation sources or energy storage to be dispatchable.

The current levels of wind resources in the ERCOT and upper Midwest can create problems with existing fossil units when excess wind energy is available or suddenly disappears. In the current system, excess wind generation can be curtailed to maintain proper balance on the system. If possible or feasible, storing wind energy would be of great benefit.

Utility-scale energy storage projects, such as compressed air energy storage and pumped hydro, are potential options where the proper geological facilities are available. Use of the existing hydro facilities in the country may be another option; however, most of these large facilities have been turned into run-of-river plants.

But the real promise lies in the opportunities to store energy at the customer level in devices that can provide dual benefits. There are currently thermal storage systems at large commercial and industrial facilities. New thermal storage systems are being developed for use in smaller commercial and residential applications. Although it is difficult to store the electricity, we can store the energy in a thermal form. These systems would allow the renewable energy to be stored in a cool form (ice) or as heat.

Batteries offer another option for storage. These can be large megawatt-size batteries or the ones planned for the PHEV. Broad deployment of these devices would provide significant storage capability for energy. Charging stations at homes and workplaces would enable utilities to control PHEV charging during all hours of the day. The advantage of having loads with storage and other types of energy storage available on the system will allow the renewable energy produced to be optimized. The ability to adjust thermal storage and PHEV charging will allow the utility to make the most of the renewable energy.

Major renewable energy zones are being identified across the country. These areas have the potential to generate thousands of MWs of non-dispatchable energy. Often, these areas are located hundreds of miles away from major load centers and will be connected via major transmission lines. The smart grid may enable power system operators to adjust load quickly to optimize this generation.

Balancing Generation with Load

Generation is used to provide regulation to maintain the system frequency as the load changes from moment to moment. The amount of regulation band reserved in the generator and the speed at which the generation can change its output are important issues in determining which generation is reserved for following the load functions. The amount of generation needed for regulation service changes from system to system.

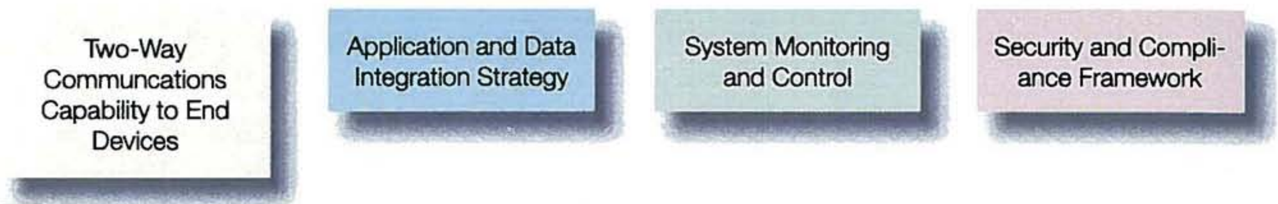
In general, the smart grid will enable better load regulation and contingency reserve operations. The current approach to satisfying load is to provide whatever the load demands from generating units. The smart grid enables operators to control more load on an ongoing basis. Adjusting load can provide the same effect for regulation as adjusting generation. The smart grid provides an opportunity to require less generation or less generation control. This reduces operating costs for the utility and requires lower generation reserves for load following.

The addition of solar and wind energy to the electric system can significantly affect the amount of regulation needed on the system. The variation in solar and wind output from minute to minute can be similar to load swings on the system, but can be of much greater magnitude. Currently, generation has to be added with high ramp rates to try to "chase" the variable output. This generation is typically gas-fired combustion turbines and engine generator sets. Smaller balancing authorities have more of a challenge in regulating with large amounts of wind energy on their systems than do larger ones.

Load changes can be implemented more quickly than generation can be moved. Load control can provide the same effect as controlling fossil generation to achieve the regulation necessary for the grid. The smart grid will enhance the ability to use load for this function.

Although the smart grid holds promise of using load to assist with generation optimization, the smart appliances, the data gathering, validation and transfer in the time frame needed by the generation controls and the overall acceptance of the concept by customers and utilities will all take several years to coalesce.

Smart Grid Building Blocks



The smart grid represents a variety of solutions for utilities to manage operations more effectively, to maintain reliability in a cost-effective manner, and to include a more informed customer in consumption decisions. Given the variety of applications and functions, a utility investing in smart grid technologies should do so in a manner that maximizes interoperability. The term interoperability has been used in the utility industry for years, but smart grid has given real reason to move beyond proprietary systems and networks to more open architecture standards to allow for the integration of disparate applications. In other words, interoperability allows for the network, system and application architecture for one smart grid application to be leveraged by another.

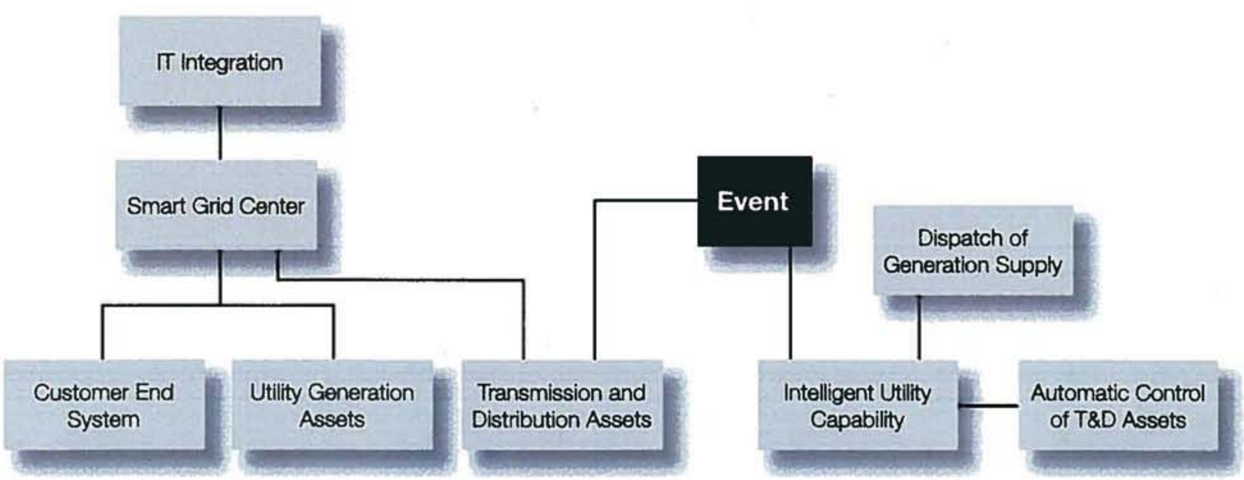
An esoteric discussion of smart grid benefits is one thing, but "what do I need to install and how much will it cost?" is the crux of what utilities need to know. What devices make up a smart grid? The answer to the question depends on where you are on the system, but there are some general attributes that are consistent across the use spectrum. These include:

- Reliable high-speed two-way communication between the utility and the power system, including customers.
- Additional control and monitoring devices.
- A system to manage increased data to get usable information.
- Increased security to protect the data and the grid.

Common Information Bus

Modeling the applications, systems and data reposi-

Figure 6: Smart Generation Capabilities



tories of smart grid solutions is an essential part of any initiative. As illustrated in the Smart Generation Capabilities model in Figure 6, each smart grid concept has been identified in the respective categories of customers, generation and T&D. Each category will generally consist of systems and applications that make up its functional area. Communication networks (further described below) carry the representative data to a centralized facility, described in this chart as "smart grid center," to allow for storing and analyzing smart grid data, which is sometimes referenced as a common information bus.

Security Measures

APPA believes that AMI and related smart grid applications may present security concerns to distribution-related assets and critical customers if the following are not addressed:

1. Review the security architecture of the communication solution of choice. Reference the AMI Security Guideline created by the DOE.
2. Perform a risk assessment of smart grid functionality and its impact to reliability.
3. Document the appropriate standards, protocols and architectures to be considered with smart grid implementations.
4. Apply regulatory requirement for NERC LSE, DP or NERC CIP compliance and regulatory functions.

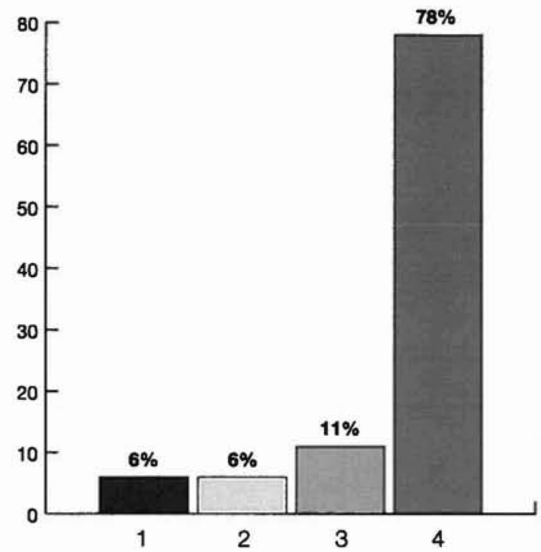
The data from the common information bus or data warehouse can be integrated with other key information repositories such as GIS, asset management and billing applications. GIS data can be used to create effective visualization applications to help aid decision making. Asset management and work management databases can be integrated into utility operational assets to more effectively troubleshoot and maintain system reliability components.

Customer information, provided by billing and customer information system applications, can be interfaced as well, especially when addressing demand-side management and load control-related functions.

The common information bus relays data that is provided using standard protocols such as DNP, or IEC61850. These protocols enable different devices and systems to communicate with each other without significantly modifying the source data. For our purposes, we will call this information energy event data. This information, once analyzed, can be exported for decision-making to key office and field personnel. Given the right information, this intelligent utility capability enables a smart grid operator to control load, integrate renewable resources or send signals to consumers to adjust their consumption.

Which aspect of smart grid security most concerns you?

1. Reliability
2. Customer privacy
3. NERC CIP compliance
4. All of the above



Security and Compliance

Smart grid infrastructure has created numerous means and methods for utilities to make new decisions based on far more points of data. This data or "payload" of grid information can consist of utility operational data and customer usage information. Both types, if left unprotected, can result in reliability and privacy risks and exposures for the utility investing in AMI or other smart grid implementations.

NERC, the electric reliability operator appointed by FERC, has enforced numerous regulatory standards for the proper control and management of electric generation, transmission and distribution. Most of the security standards are based on the idea of identifying critical transmission assets on the grid that are essentially above 100 kV. These security standards have left out smart grid networks because these technologies are using distribution infrastructure. As organizations rush toward implementing AMI and other smart grid applications that require data collection and management, they must be sure to address developing operational standards to ensure the safekeeping of the data, and the integrity of electric operations itself.

Public Power Communication Systems

- Fiber to substations in Nashville, TN; Princeton, IL; Anaheim, CA
- BPL to residences in Princeton, IL
- RF mesh in Nashville, TN, for AMI

It is important to clarify that there is no specific smart grid regulation in place that dictates reliability and security of smart grid-related applications, systems and networks. However, it is also important to note that the implications of the NERC reliability standards do not specifically rule out applying the requirements to smart grid-related activities. Therefore, APPA recommends that utilities strongly consider applying the principles of an industry standard to utility smart grid deployments. NERC CIP-002-009 and NIST 800-53 are some examples of these standards.

Network and Telecommunications

The basic element of all smart grid solutions is the ability for disparate and remote systems and end devices to communicate with each other. Many utilities have established communication between certain systems and end-device components, such as meters, relays and intelligent electronic devices (IEDs). Much of the connectivity to these systems has been minimal or limited, one-way low-bandwidth data streams. The advent of TCP/IP, wireless networks and radio networks has created the ability for the end devices to have greater functionality. This new functionality has lead many experts to identify smart devices such as:

- Smart meters
- Smart relays
- Smart IEDs
- Smart controllers
- Automated reclosures
- Sectionalizing

In essence, the concept of SCADA (supervisory control and data acquisition) has now been broadened to include smart devices that will enable the smart grid. For instance, smart meters, in addition to recording energy consumption, can now provide control commands to connected appliances or HVAC controllers. This capability provides end devices with more data, which leads to more intelligent decisions to operate the grid.

The term AMI (advanced metering infrastructure) has emerged from the concept of automatic meter reading. The premise of AMI is to create a robust, two-way communications pathway to smart meters. However, AMI may not be the communication solution for distribution automation, condition-based monitoring or other smart grid concepts previously discussed.

Instead of considering AMI and smart metering the core component of smart grid solutions, evaluate an overall communications strategy and identify where end devices can become more intelligent by increasing the amount of data the device can receive. The increased data, payload, is essential to building a smart network to perform the promises of the smart grid.

Ultimately, the smart grid can be enabled by different communication strategies. The key question that each utility will need to answer is "What is the most cost-effective communication technology available to provide two-way communications to end devices?" Consider the following communications technologies:

- 2.5G-4G cellular deployment
- BPL
- Wi-Fi/mesh deployment
- Wireline Communication to Field Deployment
- Broadband
- ZigBee and home area networks

2.5G-4G Cellular Deployment

One of the most attractive wireless deployments for utilities is 2.5 and 4G cellular deployments. This deployment scenario consists of contracting with a third-party wireless service provider, who typically already has network infrastructure deployed in many metropolitan service areas. Once contracted, utilities would purchase a network card to access the network. With a small piece of software installed (provided by the third-party wireless carrier), utilities can then get instant and "always-on" connectivity to the Internet. In negotiations with the service provider, utilities could make the network connection become a seamless corporate network connection. From there, the devices in the field would receive a network address from the service provider and then be connected to the utilities network throughout the entire metropolitan area.

The advantages of deploying a solution like this consist of:

- Low initial infrastructure capital cost investment
- Quick to deploy
- Infrastructure already in place
- Service level agreements (SLA) with wireless carrier
- Robust coverage area

Some of the disadvantages of this solution:
- High recurring cost of the leased communication services
- SLA for connection restoration that may not meet utility standards

BPL

Broadband over power line (BPL) technology uses the electric power infrastructure (owned by utilities) to conduct data communications. BPL solves the coverage area limitation of Wi-Fi in the city by deploying Wi-Fi technologies in conjunction with BPL technologies. BPL could be deployed across a vast majority of the utilities' electrical infrastructure delivering and "lighting up" the power lines with data communications.

The advantages of deploying a solution like this consist of:
- SLA for licensing is not an issue
- Utilizes existing lines to carry a communications signal

Some of the disadvantages of this solution:
- May cause and receive interference from licensed radio frequencies
- Regulations permitting BPL vary by area
- Not ideal for critical operations
- Transformers block the RF signal on the line

Wi-Fi/Mesh Deployment

Another potential deployment of a wireless network for utility field devices could be in the form of Wi-Fi hotspots. Wi-Fi is a rapidly expanding and popular technology. Today, some new metering devices are being manufactured and shipped with Wi-Fi technology already integrated into the hardware itself. Intel, Cisco, Atheros, and other vendors have pushed this technology into the marketplace with great success. The availability and cost associated with Wi-Fi technologies are relatively low.

However, interference and coverage area hinder Wi-Fi's large-scale deployment. Wi-Fi operates in an unlicensed frequency range, so any person or entity can operate another Wi-Fi device on that frequency. Given the pervasiveness of Wi-Fi and the potential interference, this could be a challenging issue in the future when more and more Wi-Fi devices are deployed.

Although interference is an issue, there are constructive ways to deploy Wi-Fi access points that allow some potential overlap by using different channels.

Coverage area is another challenge associated with Wi-Fi. However, Wi-Fi mesh technologies are available to extend connectivity by creating a web of Wi-Fi hotspots to carry a signal much greater distances.

Some of the advantages are:
- Easy installation, 10 to 30 feet above ground level (mount on streetlights)
- Unlicensed, no frequency coordination or permitting
- Low capacity, easy to justify
- Point to point or point to multipoint, fixed or mobile
- Immune from substation ground potential rise (GPR)

Some of the disadvantages are:
- Expensive, requires many access points for coverage
- Low throughput because of store-and-forward operation
- Can receive interference
- Can be affected by weather and atmospheric conditions, building materials
- Low capacity, existing channels may be in use
- Not designed for critical operations

Wireline Communication to Field Deployment

A final potential network connection solution for the field devices is through traditional wireline capabilities. This solution yields the lowest operational costs if a utility already has a substantial wireline infrastructure. This deployment scenario consists of not enabling the field devices with wireless connectivity at all. In this case, the field device would have to be physically connected to the WAN to perform two-way communications. In many cases where a utility already has existing dark fiber in place, smart grid applications can be a great use of the existing bandwidth. For utilities that do not have an existing wireline infrastructure, wireless is most likely the best option.

Some of the advantages are:
- Very high capacity and reliability
- Scalable (from 1 DS-0 to 96 OC-192)
- Supports any mix of traffic (TDM, ethernet, serial, video, etc.)
- Multiple routes

Some of the disadvantages are:

- Fiber optics can be expensive, requires high density of channels to justify
- Installation of support infrastructure
- Personnel must be qualified to manage and maintain a diverse high-speed communications network

Broadband

DSL (digital subscriber lines) and cable modems have been used in recent years for continuously connected, high-speed Internet access for homes and small businesses. Given the nature of connectivity, broadband Internet connections present an interesting opportunity for utilities and consumers alike. In a nutshell, SCADA functions have been limited to utility-based operations. Now this concept can be extended to the home by connecting to broadband-connected energy management servers. Microsoft is currently developing technology that can integrate the concept of energy management into a home automation system for energy conscious consumers.

Some of the advantages are:

- Communication infrastructure is already provided making use of the customer-owned HSD line inexpensive
- Many times a wireless router is already in place, simplifying wireless communication to the meter and to a home energy management system

Some of the disadvantages are:

- If using a customer-owned communication system, utility network security needs to be increased
- Cable or DSL outage restoration may not meet the same restoration requirements as the utility
- Agreement between the utility and the customer about what will be transmitted across the customers network

ZigBee and HANs

The HAN (home area network) is how homes, buildings and businesses can be "linked" to the smart grid. The concept of the HAN is to create a network similar to the one used for PCs and laptops, but instead be used to connect high-energy appliances such as air conditioners, dishwashers and pool pumps. The two prevailing HAN standards are ZigBee and Homeplug. Zigbee and Homeplug have formed an alliance to ensure that the manufacturer devices that utilize this technology will be able to interact with each other as well as a home energy management system. Zigbee creates a wireless network similar to a W-Fi mesh within the home. Homeplug utilizes the power line wiring inside of a structure, thus making it similar to BPL. Many appliances today are attempting to conform to the ZigBee/Homeplug Alliance standard so electronic devices at homes and business can work in concert to monitor and consume electricity.

Data Management

The meters and HAN devices attached to the smart grid will generate more data than utilities have ever had to deal with. One utility's preliminary estimate is that the smart grid will generate 22 gigabytes of data each day from its 2 million customers. The data generated by the smart grid has to be collected and analyzed before the grid becomes truly smart. The information about daily usage provided to a customer influences only one user and is a small part of the larger picture. Each utility must collect and analyze the data from all of its customers to leverage the potential of the grid through demand response, dynamic rates, and other programs.

In preparation for using this data, utilities should develop data management plans defined by what the data will be used for. Data management plans should follow the natural lifecycle of the data from collection, analysis, integration, and eventual archival. Beyond basic analysis, the plans should also describe how the data can be integrated with other utility data—financial, GIS, asset management, outage, and customer data—to achieve the most benefit from its collection and analysis. Data management plans must extend beyond collection and analysis to incorporate storage during analysis, archiving the raw data, and disaster recovery in the event of an outage during the lifecycle.

Because the real value of the data is the information created from it, utilities should seek tools and partnerships that allow them to automate data management, validation, and processing. Enterprise-level relational database management systems like Oracle are required to handle the large data sets and have the necessary management tools. These systems are probably in use for the other financial, billing, and asset management systems in the utility and will reduce the hurdles to integration. In some instances, utilities may have to leave legacy systems behind in order to integrate business data with meter and HAN data. While open source tools may provide a lower initial cost, they may not be as well supported or have the necessary enterprise level tools and administrators.

Standards

With the advent of smart grid upon us, utilities are considering the deployment of advanced metering infrastructure (AMI) with a robust two-way communication as a foundation for the deployment of their smart grid networks.

Intelligent electronic devices, smart meters, and Internet connections, all of which communicate with home area networks (HANs), comprise a diverse offering of communication technologies. Various vendors are trying to compete by bringing their own product offerings into the smart grid space. With their offerings, they bring their own proprietary protocol, which becomes challenging for utilities as they attempt to deploy a ubiquitous network, ideally with a "plug and play" approach. Having an "open" communication standard that allows various smart grid devices to communicate and network together using a common protocol is imperative if utilities and consumers are to maximize the smart grid at minimal cost.

Companies have started working toward standards. ZigBee Alliance is an association of companies working together to offer reliable, low-power, wireless network that offers monitoring and control products based on open standards. ZigBee Smart Energy under the ZigBee Alliance offers utilities and energy service providers secure, easy-to-use wireless home area networks (HAN) to directly communicate with thermostats and other smart appliances using open standards. Like ZigBee, the HomePlug Powerline Alliance has been created to provide a forum for the creation of open specifications for high-speed home power line networking products and services.

At the national level, the National Institute of Standards and Technology (NIST) has announced an aggressive three-phase program to develop key technical standards for an intelligent power distribution grid by the end of 2009. The smart grid program was established in the Energy Independence and Security Act of 2007; the smart grid has been identified as an important element of the Obama administration's economic recovery program with the promise of creating jobs, contributing to energy independence and curbing greenhouse gas emissions. With money for developing and fielding new electric grid technology becoming available with the economic stimulus law, industry now needs standards for interoperability and security.

NIST has outlined a three-phase approach to standards development:

- Develop a consensus among utilities, equipment suppliers, consumers, standards developers and other stakeholders on needed standards; and producing a smart grid architecture, an initial set of standards to support implementation and plans for developing remaining standards by early fall.
- Launch formal partnerships to develop the remaining needed standards.
- Develop a program for testing and certification to ensure that smart grid equipment and systems comply with standards.

The Energy Independence and Security Act gave DOE the overall lead of the smart grid program. NIST was assigned the job of developing a framework of standards and protocols to ensure interoperability and security. Final standards will be approved by the Federal Energy Regulatory Commission, which has regulatory authority over the interstate industry.

Data Standards

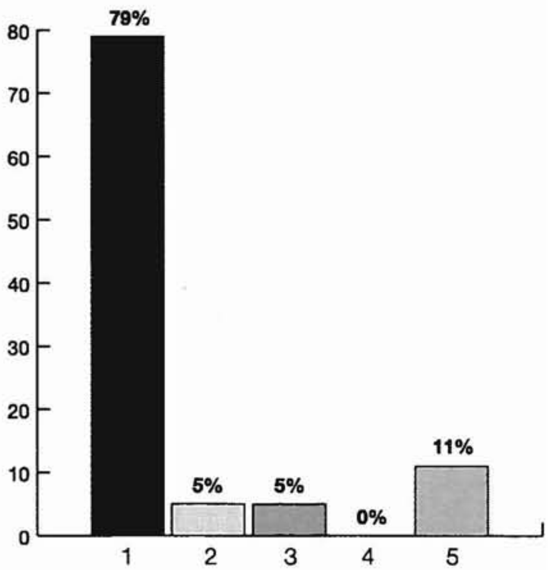
As utilities are planning their smart grid deployments, they should identify vendors who follow standard data formats. Data from devices that output standardized XML will be easier to load into a database and integrate than data in a vendor-specific or proprietary format. Utilities should follow industry standards and best practices for validating and storing data to improve data quality and make interoperability with enterprise applications, GIS systems, and visualization tools seamless.

Where Do We Go From Here?

Many of the survey respondents described varying stages of smart grid implementations. Of the utilities that stated they are still in the planning stages, many have already laid the foundation for future smart grid investments. These respondents stated that they have fiber to their key substations; others mentioned that they have invested in AMR, while others have focused on system integration of outage management and energy management functions. These implementations can all be effectively leveraged and integrated into other smart grid solutions.

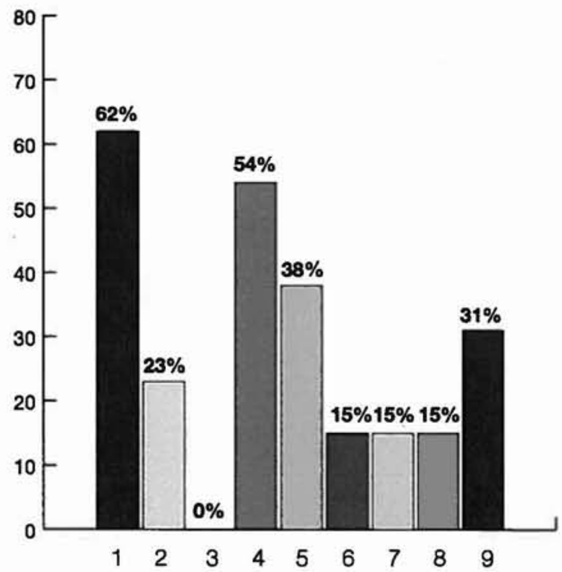
What stage of smart grid is your utility currently in?

1. Study-implementation within 5 years
2. Pilot-implementation within one year
3. Partial implementation in progress
4. Full implementation- equipment and software installed and working
5. No plans within five years



Which of the following are you already engaged in?

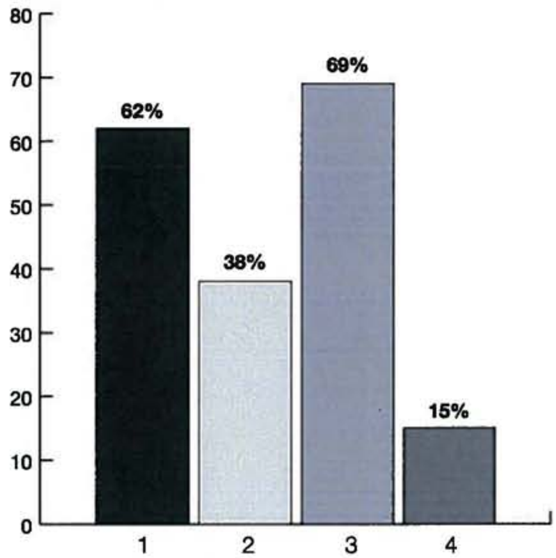
1. AMR
2. Time-of-use rates
3. Real-time pricing
4. Distributed automation
5. Demand response/load control
6. Remote connect disconnect
7. Distributed generation integration
8. Condition-based monitoring
9. Real-time outage management



The key to developing a smart grid plan is identifying how similar functions and technologies "overlap" so that incremental investments in particular solutions can be maximized and leveraged. For example, if a utility already has a fiber backbone in place to many key distribution substations, does it make sense to purchase a meter data management system? Should a

What is the most likely method to recover the cost of smart grid investment?

1. Base rate increase
2. Customer surcharge
3. Stimulus package/grants
4. Other



utility invest in outage management system if the only indicators of an outage are customer calls? Should the utility offer real-time energy consumption data to customers if time-of-use rates are not real-time as well?

Almost all APPA members operate a distribution system and have retail customers. In these two areas lie the vast majority of smart grid activities. In the distribution area, development of SCADA and distribution automation is the focus. For the customer, getting better connected is the key. Advanced meters and home area networks are needed to fully engage the customer.

Today's utilities need to understand the tech-savvy nature of the current generation. They use the latest technologies and are connected 24/7. It's important that public power utilities stay constantly connected to meet the ever-changing and ever-increasing demand for real-time information and real-time results.

In looking at the deployment of the smart grid, there will be benefits that accrue to the customers, the utility, and society in general. The business case for the investment in smart grid is supported by these three areas. Cost recovery for system installations by regulated utilities have come from a variety of options, such as:

- Surcharges for limited time
- General rate treatment
- Cost "trackers"

The business case for the investment in smart grid should take the balancing of benefits with costs into consideration. The approach to funding the smart grid for public power utilities can take a mix of approaches. Consideration of a portion of the funds to be associated with "cost of business" may place the recovery of these amounts with general rate increases. A portion might be allocated to a customer surcharge or tracker. Another portion might be obtained by reducing transfers to the city from consideration of societal and economic development activities. Various government programs are developing to cost share in these initial installations and APPA recommends that utilities take advantage of all grant incentives from state and national programs. (Figure 7)

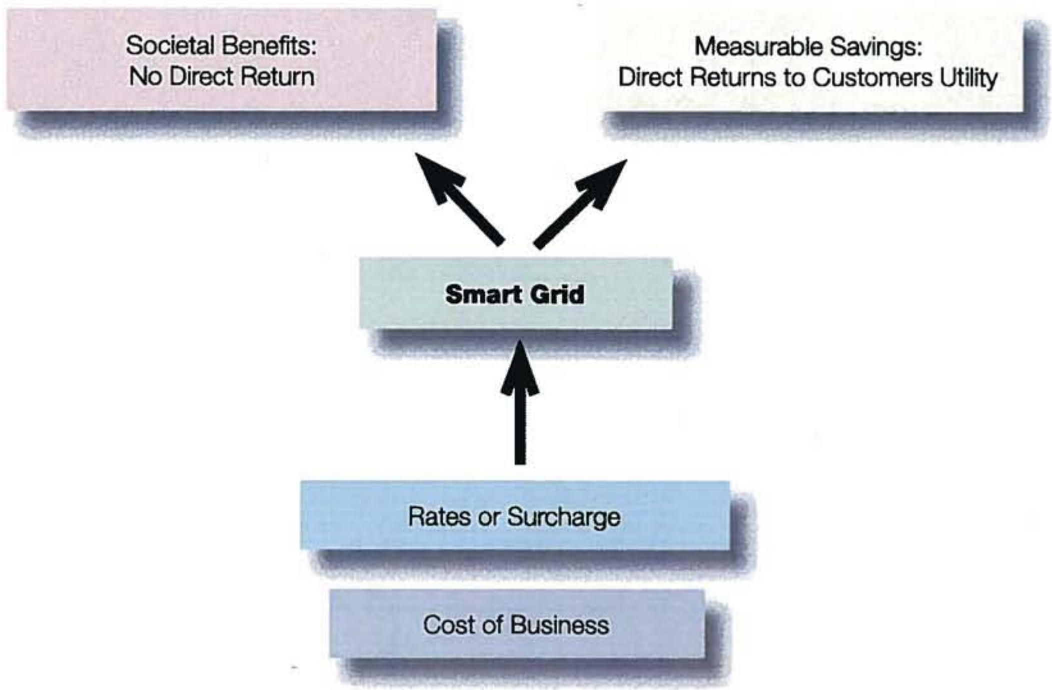
Customer Education

For an effective smart grid development, it will be necessary to bring the consumer along in the development process. During the defining stages of the system, it would be beneficial to use consumer groups and surveys to gain feedback on various aspects of the smart grid you were planning to implement in your utility. This would allow the utility to begin to educate the consumer and shape expectations on what the smart grid could do for the consumer. It also allows the consumer to understand what aspects of the smart grid can be used today and what features are not quite commercial.

Consumers also need to understand what their role will be in the smart grid. How involved will they need to be to see benefits in their bills? What will be automated? What types of information will they be seeing? Are they going to have to learn a new rate structure? There will be a variety of questions from the consumer on their role and the utility must be ready with the answers for the system to be successful.

Education can be provided via the Internet, bill stuffers, service center demonstrations and a variety of other means. The schedule for this education should be such that it is ahead of the major rollout of the system.

Figure 7



Moving Forward

As mentioned throughout this guide, there is no one-size-fits-all approach to smart grid because there are various solutions and building block combinations that can make sense to a given utility. However, some general conclusions can be made about its business drivers and benefits. In terms of a Road Map for Smart Grid, we have determined four major categories or "tracks" where many utilities will engage. (Figure 8)

Smart Grid Development Strategy

As stated, a utility may take various paths down the road of smart grid deployments. For utilities in the early stages of smart grid, we have summarized a deployment strategy for consideration.

The first step is to create a business case. The business case does not have to be elaborate, but it should clearly communicate the goals, anticipated benefits and associated costs relative to the investment. Usually the first step in creating the business case is performing a needs analysis. We prefer to call it a Smart Grid Readiness Assessment.

As a first step, each utility should establish its vision

Figure 8: Four major categories or "track" along the Road Map for Smart Grid

Advanced Metering	Operational Improvement Track	Smart Balancing Track	Reliability Management Track
Smart Meters	Asset Management Condition Based Monitoring	Load Control	GIS
Communication Upgrade	• Transformer	Thermal Storage	Asset Management
Meter data Management	• Breakers	Distributed Generation	Distribution
In-home Displays	Maintenance	Residential Control	Management System
Home Area Network	Management	• AC	Outage Management
Advanced Billing		• Pool Pumps	Substation Automation
		Time of Use Pricing	Feeder Automation
		Smart Charge of PHEVs	Power Quality
		Renewable Energy	Monitoring

for the smart grid it wants to develop. Starting from the customer on back to power supply, identify the expected benefits of the installation and data obtained. Typically, load-serving entities have significant customer service and distribution reliability improvements identified. Expanded use of individual customer data can help the enterprise in the development of rates, load forecasting, new service offerings, asset management and a host of other areas.

As part of the readiness assessment, the utility should identify components of the smart grid that are already in place. For instance, many utilities have SCADA systems, distribution automation, and other assets that will be integrated into the smart grid.

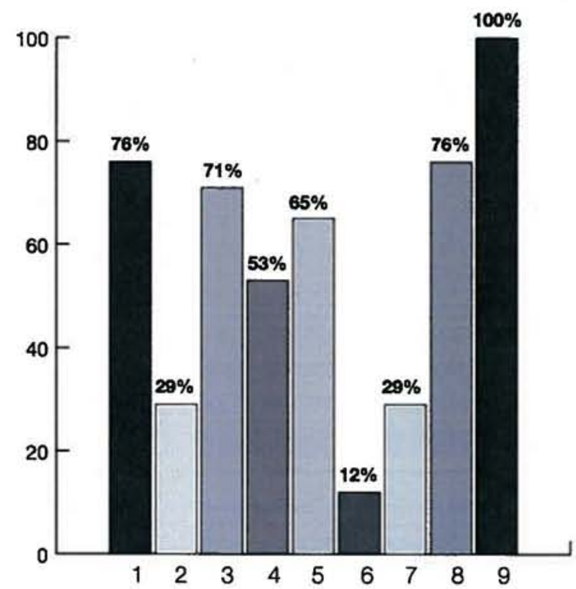
Secondly, many utility respondents mentioned they were in the pilot stage of their smart grid efforts. APPA recommends any utility strongly consider implementing pilot programs prior to the full implementation of a program to ensure that key objectives can be met and lessons learned can be applied.

Finally, present justification results to stakeholders and/or regulatory bodies to obtain funding or approval to move forward with smart grid solutions. Be sure to clearly communicate the benefits to reliability, utility operations, customer relations or overall community or society. Once the buy-in is obtained, make the smart grid program a campaign in the organization and identify a champion to market the program to ensure the parties involved understand the incremental benefits throughout the deployment.

It is important to understand that there are going to be vast changes in the technologies deployed for smart grid activities as utilities move forward with actual implementation. Already, smart grid start-up companies are bemoaning the slow implementation of the technologies by conservative utilities. As the early

Select the IT back office applications you would most like to see integrated with your smart grid initiative.

1. Customer billing
2. Energy market applications
3. GIS
4. Work order management
5. Asset management
6. Auto cad
7. Historian
8. Data warehouse
9. Outage management



Pilots of various types are underway:

- Anaheim, CA is installing Smart Thermostats to see how customers respond to in-house display of consumption.
- Princeton, IL is moving to add automatic outage detection at each meter using its BPL system.
- Advanced Meter Infrastructure pilot programs are underway in Anaheim, CA; Naperville, IL; Nashville, TN among others.

Smart Grid Readiness Assessment -- Analyze utility capabilities in the following areas:

- Establish goals for the deployment of Smart Grid
- Operational Capabilities – evaluate methods to improve the ability to monitor or control electric power functions.
- Reliability Improvement Categories – using existing measures (such as SAIFI or CAIDI) and identify means and measures to minimize outage frequency, duration and overall quality of service to customers.
- Cost Improvement Potential – recognizing cost issues associated with peak demand by assessing the potential savings by implementing load reduction or energy efficiency programs.
- Economic Stimulus Options – often technology upgrades may create other ways for utilities to make money. For municipals, evaluate other services that can be offered to city government organizations.
- Technology Gap Analysis – most importantly, inventory the relevant technologies that make up the operations of the utility and identity where technology improvements in applications, control systems and communications can be made to achieve the benefits determined in the aforementioned areas.

adopter utilities work with vendors to prove concepts, as more aspects of the system are incorporated into actual service and as utilities and customers understand what is actually usable in practice as opposed to theory, the components of the smart grid will become better defined. The main issue is to get involved with reviewing how your system might be enhanced by an investment in the smart grid components that are right for you and your customers.

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